July 1961
75¢

SEMICONDUCTOR PRODUCTS

R&D • DESIGN • TECHNOLOGY • APPLICATIONS

Typical Aluminum—Silicon Bond to Gold formed at 500°C for one minute.

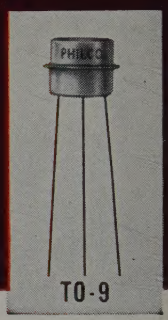
The Tunnel Diode Pair
Introduction To The Avalanche Transistor
Gold Alloying To Eutectic Surfaces

150 mw POWER DISSIPATION MADT®

NEW LINK

in Industry's Strongest Chain of Transistor Performance

PHILCO 2N2048 GERMANIUM SWITCH



ABSOLUTE MAXIMUM RATINGS

Storage Temperature	−65 to +100°C
Collector Voltage, V_{CB}	−20 volts
Collector Voltage, V_{CES}	−20 volts
Collector Voltage, V_{CEO}	−15 volts
Collector Current, I_C	−100 ma
Total Device Dissipation @ 25°C	150 mw

ELECTRICAL CHARACTERISTICS (@ 25° C)

Characteristics	Conditions	Min.	Max.	
Collector Cutoff Current, I_{CBO}	V_{CB} = −5v		3	μa
DC Current Amplification Factor, h_{FE}	V_{CE} = −0.5v, I_C = −50 ma	35		
DC Current Amplification Factor, h_{FE}	V_{CE} = −0.5v, I_C = −10 ma	50	300	
Collector Saturation Voltage, $V_{CE\ (SAT)}$	I_C = −10 ma, I_B = −0.5 ma	.050	0.140	volt
Base Input Voltage, V_{BE}	I_C = −10 ma, I_B = −0.5 ma	0.25	0.35	volt
Hole Storage Factor, K's	I_B = −2.5 ma		100	nsec
Gain Bandwidth Product, f_T	V_{CE} = −10v, I_E = −6ma	150		mc

Philco's new 2N2048 is the forerunner of a broad line of 150 mw MADT switching transistors. The new power dissipation capability is available in uniformly reliable high-speed units, at surprisingly low cost, via proven MADT automation.

Intended for both saturated and non-saturated logic circuits, the Philco 2N2048 gives you more than comparably priced transistors—more drive per transistor, more switching speed per dollar invested in transistors, and the extra capability of extra power dissipation for applications that require it.

Philco 2N2048 features include minimum h_{FE} of 50, maximum V(SAT) of 0.14V., minimum f_T of 150 mc., and tightly controlled V_{BE} ranging from 0.25V. minimum to 0.35V. maximum. For complete information write Dept. SP761.

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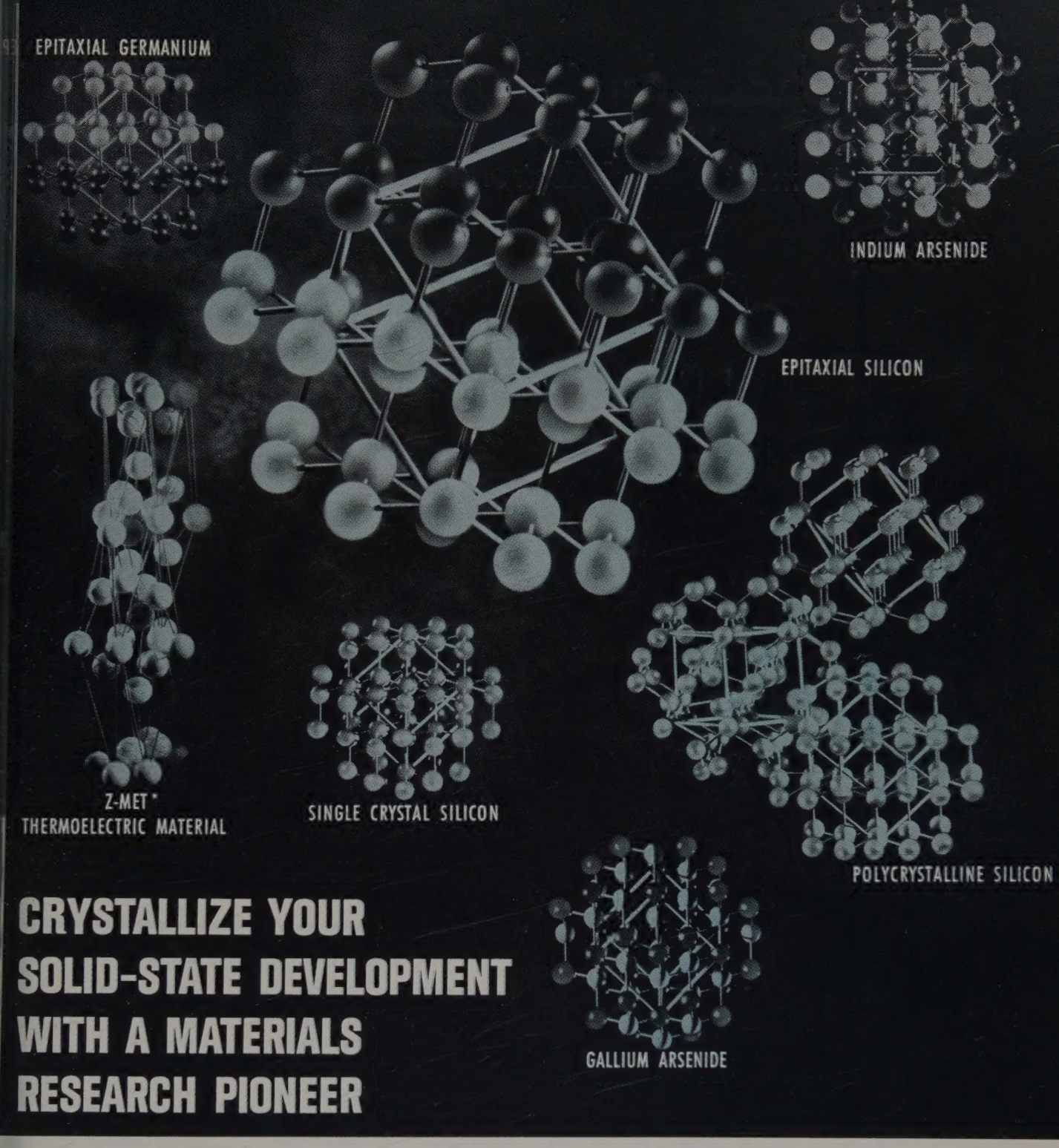

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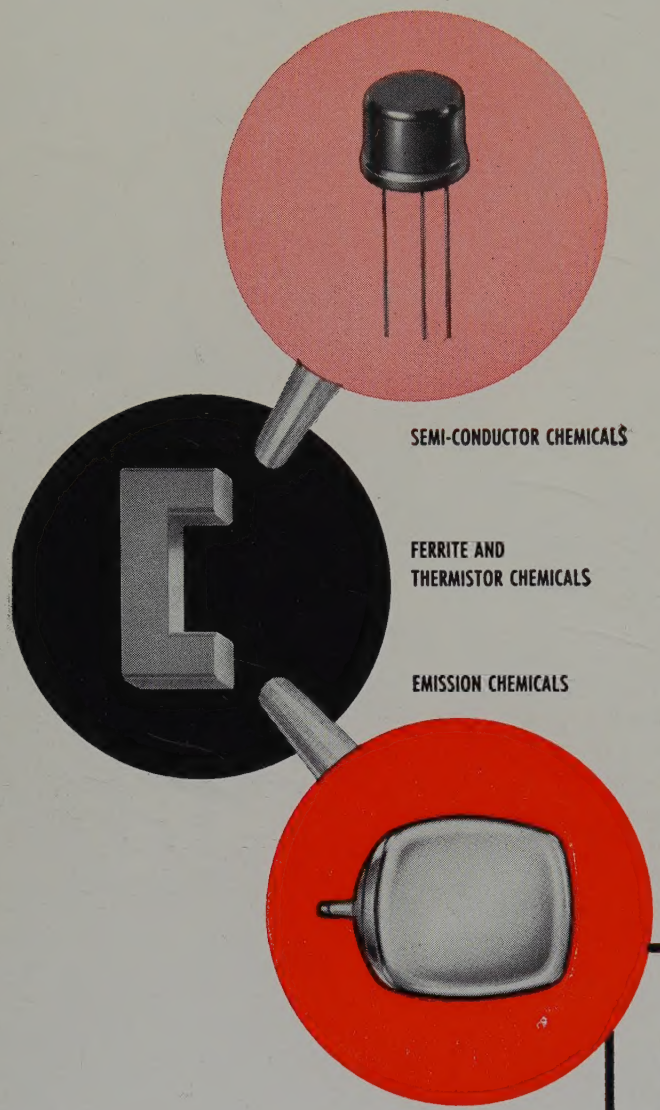
to meet critical electronic manufacturing needs



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Aluminum Sulfate	Ether, Anhydrous	Petroleum Ether
Ammonium Carbonate	Hydrochloric Acid	Potassium Dichromate
Ammonium Chloride	Hydrofluoric Acid	Potassium Hydroxide
Ammonium Hydroxide	Hydrogen Peroxide,	iso-Propyl Alcohol
Ammonium Phosphate	30% and 3% Solution	Radio Mixture No. 3
Antimony Trioxide	Lithium Carbonate	Silicic Acid
Barium Acetate	Lithium Chloride	Sodium Carbonate
Barium Carbonate	Lithium Nitrate	Sodium Chloride
Barium Fluoride	Lithium Sulfate	Sodium Hydroxide
Barium Nitrate	Magnesium Carbonate	Sodium Phosphate Dibasic
Benzene	Magnesium Chloride	Strontium Carbonate
Boric Acid	Magnesium Oxide	Strontium Nitrate
Cadmium Chloride	Manganese Dioxide	Sulfuric Acid
Cadmium Nitrate	Manganese Nitrate	Toluene
Cadmium Sulfate	Manganese Sesquioxide	Trichloroethylene
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Calcium Chloride	Methanol	Xylene
Calcium Fluoride	Nickel Carbonate	Zinc Chloride
Calcium Nitrate	Nickel Oxide, Black	Zinc Nitrate
Calcium Phosphate	Nickel Oxide, Green	Zinc Oxide
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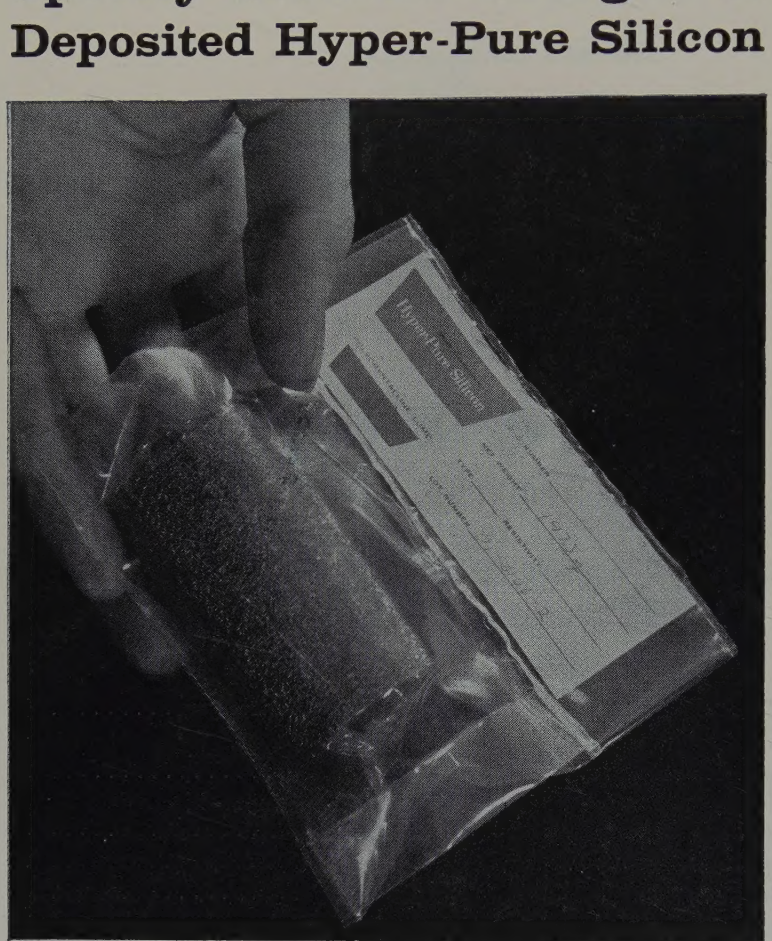
Front Cover

A typical bond formed between aluminum-silicon and gold at 500° C for a period of one minute. Photo courtesy Alloys Unlimited, Inc. (See article starting on page 29.)

(Part 4)

The Untouchables

Specify Crucible Charges of Deposited Hyper-Pure Silicon



Pre-packaged single piece crucible charges . . . in sizes and weights to meet the exact requirements of your Czochralski crystal growing equipment . . . are now available from Dow Corning.

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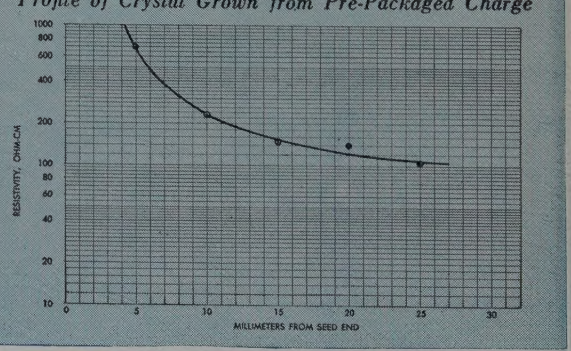
Profile of Crystal Grown from Pre-Packaged Charge



Free brochure — "Hyper-Pure Silicon for Semiconductor Devices." Write Dept. 1819

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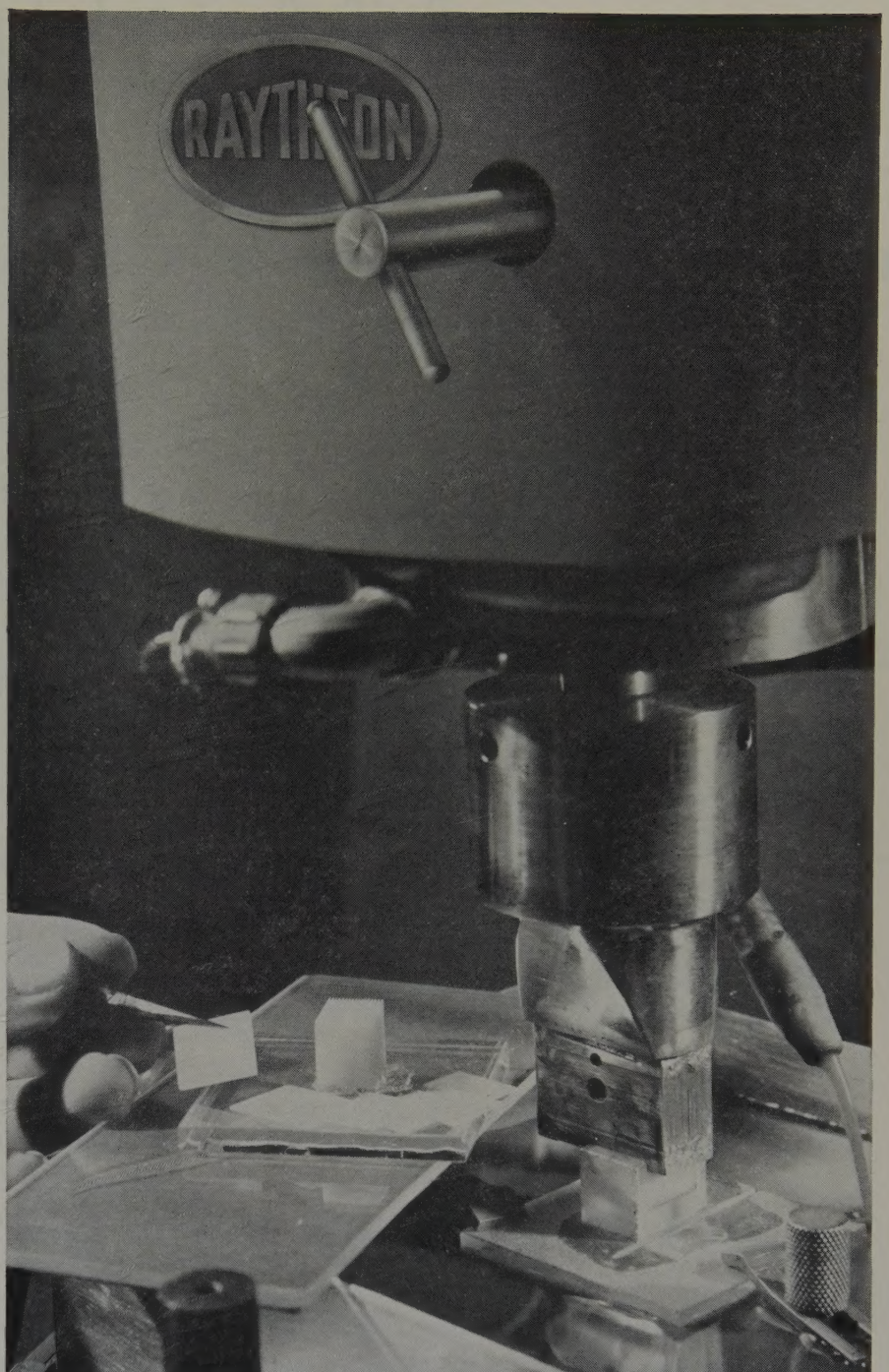

Raytheon Ultrasonic Impact Grinders are widely used for slicing of semiconductor wafers, as shown, and in later dicing of the wafers. Other machining operations include drilling, engraving, broaching, trepanning, shaping, shaving, lapping etc. Driven against the work with an impact force of 150,000 times its own weight, NORBIDE boron carbide grain is recommended by the Raytheon Company as the "cool" abrasive that meets every requirement for high precision, trouble-free cutting action.

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PSI depends on ultra-high purity Baker & Adamson "Electronic Grade" Chemicals to perform important functions in the manufacture of high performance, high reliability semi-conductor devices. These chemicals meet the strictest standards for purity and uniformity...hold impurities to the lowest levels ever attained.

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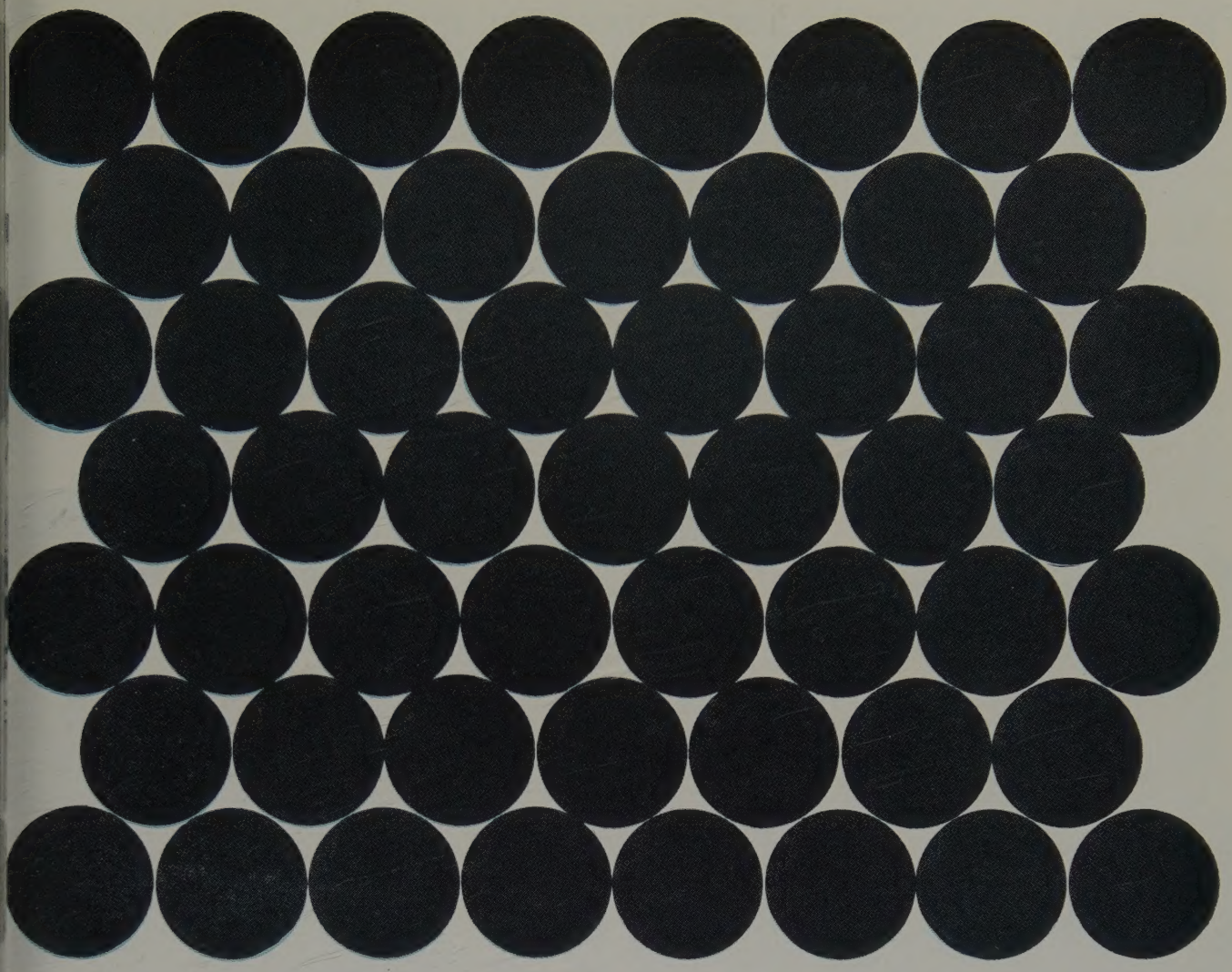

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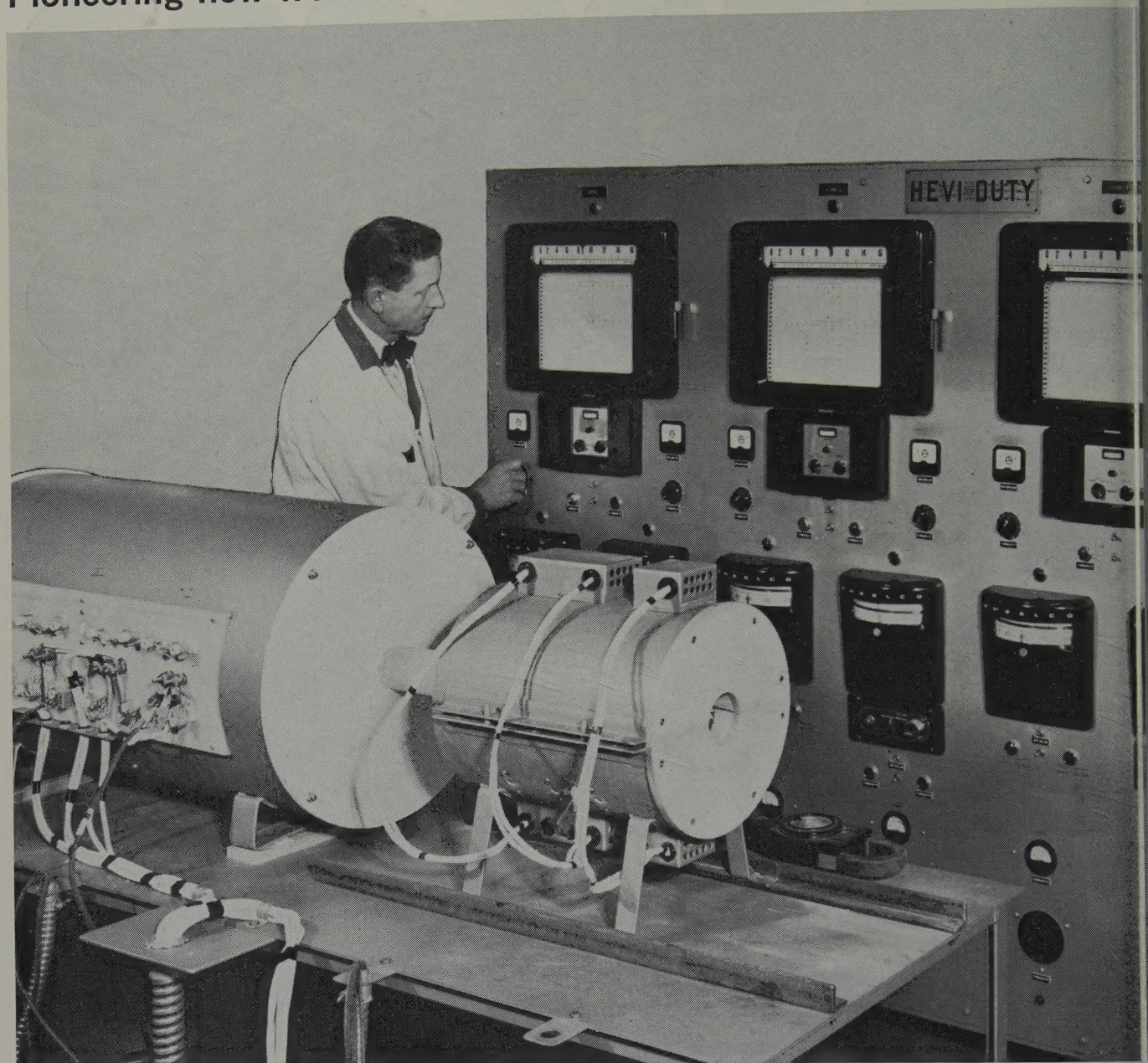

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device yields
with
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The 0-8 achieves temperature uniformity of 3° at 0 to 800°C and is the low cost oven that functions perfectly at temperatures above 250°C and pressures on the 6th scale without custom modification.

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Up to 800°C.

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*terminology recommended by Standards Committee of American Vacuum Society

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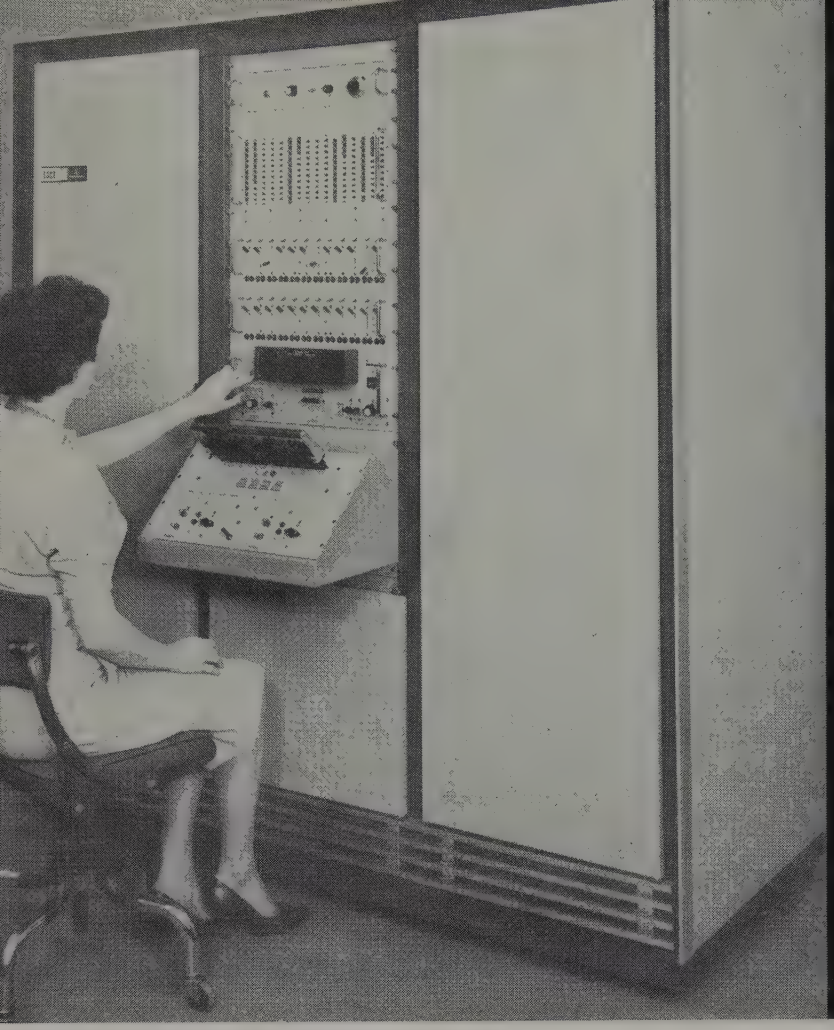

new from TI

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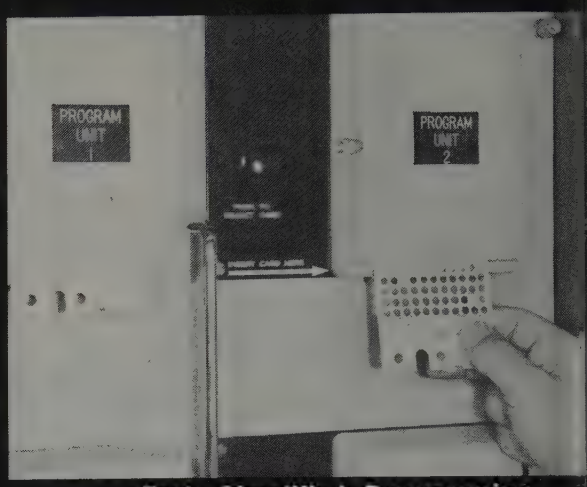
TRANSISTOR AND COMPONENT TEST



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TACT is a universally applicable transistor and component tester that will meet both present and future requirements without undue investment. It is a sequentially controlled system which advances through as many as 24 test parameters, applying pre-programmed test limits and visually reading out and/or recording measured results. Time-proved test circuitry is combined with punched-card programming to produce a highly accurate system of high sequential testing speeds.

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Repeatability of Testing is maximized by punched-card programming and remote control of common test circuitry. Program cards can be retained and used indefinitely, assuring high repeatability and a permanent record of test conditions.

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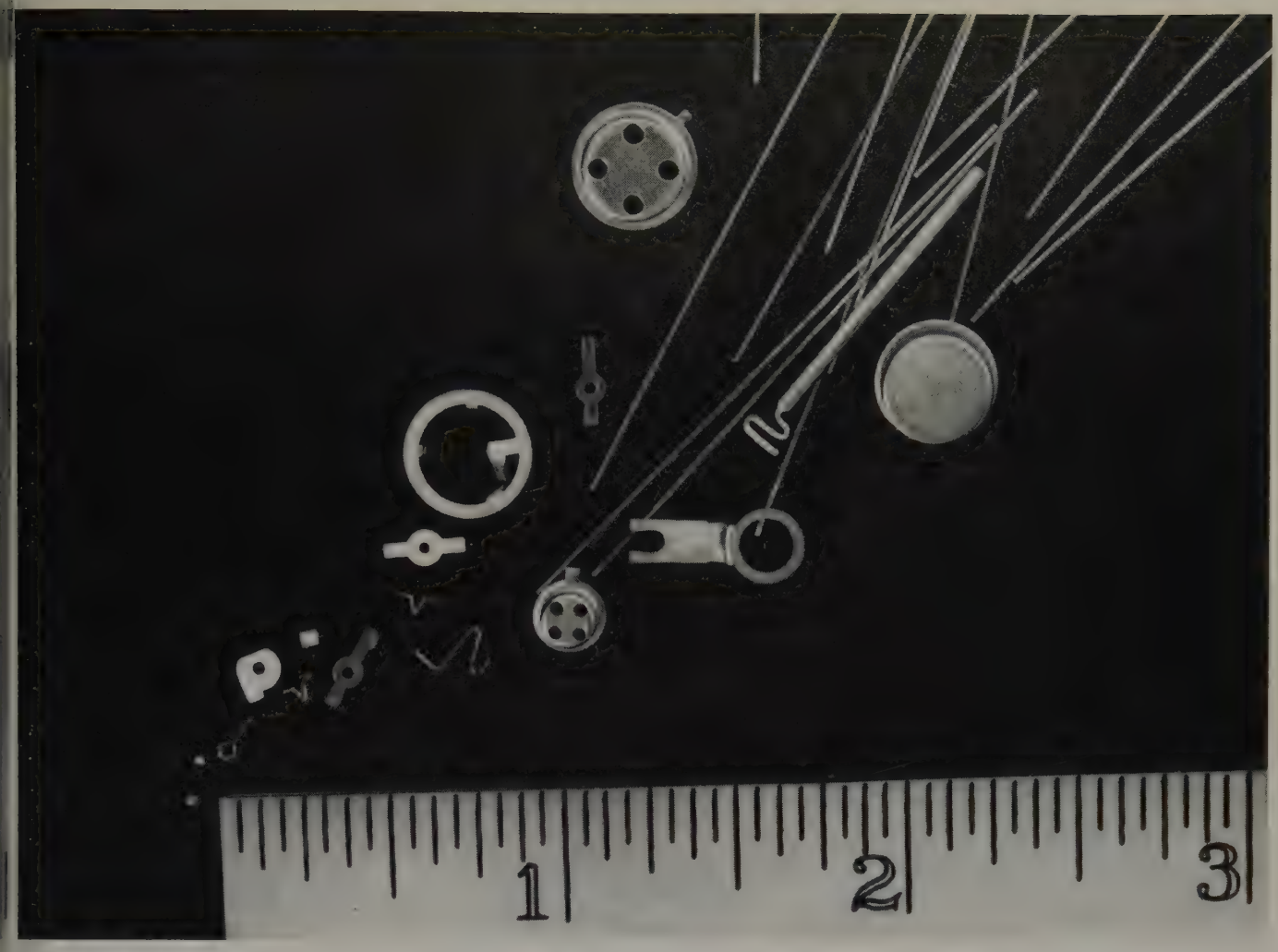

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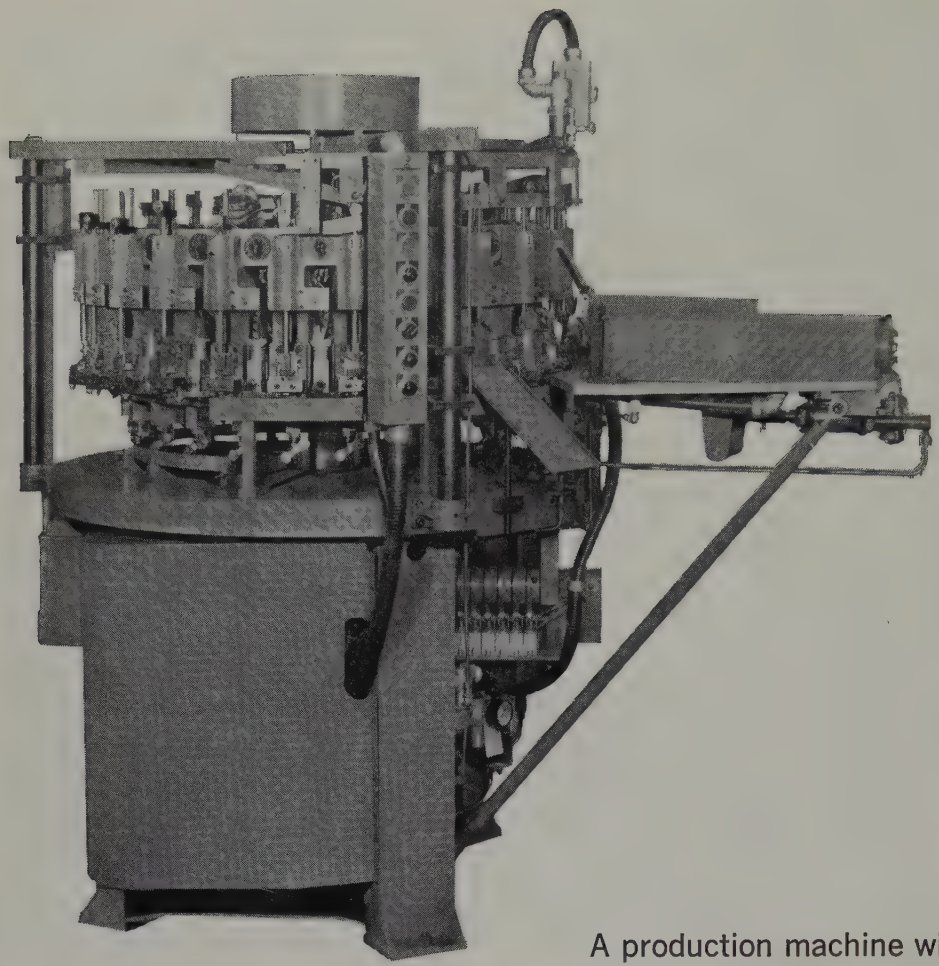

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Editorial . . .

Semiconductor Diamonds

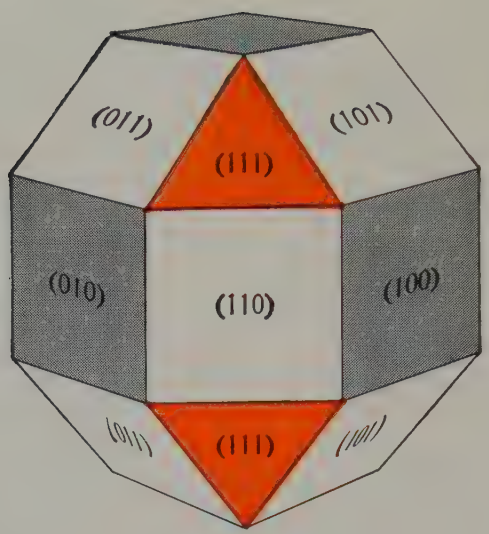
Although carbon, like silicon and germanium, is an element of Group IV, its uses as semiconductor are extremely limited. Diamond, for example, has a large intrinsic energy gap, of the order of 5.6 ev, and therefore acts almost as an insulator. For this reason the discovery by J. F. H. Custers in 1952 that some diamonds from Premier Mine in South Africa has semiconductor properties arose considerable interest. These diamonds, called Type II, possess unknown impurity dopants, probably of acceptor type, Group III, which add acceptor levels inside the energy gap, in the vicinity of the valence band. In practice donor levels also are present, but the net behavior of the crystal is that of a p-type semiconductor.

Various investigations have been developed for the purpose of measuring the crystal properties and deriving the corresponding energy level structure. These investigations are limited by difficulties due to the scarcity of the crystals, to their small size, to the presence of stochiometric imperfections, and to the lack of direct synthesis techniques under controlled conditions.

The properties which have been measured are the resistivity, the Hall constant, the optical absorption, the photoconductive response to various radiations, the electroluminescence, the rectification characteristic, etc. For example, optical phosphorescence bands at 466.5 mμ, 531 mμ and 572 mμ have been measured. Through direct application of relations derived from the hydrogen-like structure it has been computed that a major acceptor level is at 0.34 ev, that the effective hole mass is 0.25 times the free electron mass, that the density of acceptor impurities is 63×10^{15} cm^{-3}, that the Hall mobility is 1260 cm^2/volt sec at room temperature, while the magnetoresistance effect mobility is 3800 cm^2/volt sec. Donor level concentrations of the order of 2×10^{15} cm^{-3} have also been measured, but the corresponding location of the level has not been determined.

Similarly the structure of the constant energy curves has not been studied. In the cases of germanium and silicon these curves present valleys in the proximity of the edge of the conduction band and appear as "warped" spheres near the edge of the valence band. Information about the band structure near such edges is obtained by means of the cyclotron resonance experiment. In this case, applying a d-c magnetic field H and an r-f electric field transverse to H, of frequency equal to the cyclotron frequency $w_c = 9Hm^*c$, it is found that the electrons absorb energy from the r-f field. If the lifetime between collisions is larger than $1/w_c$, the resonance absorption of power occurs. Its peak position gives information about the effective electron mass.

Although extensive measurements have been made so far on the properties of these diamonds, much work is to be done to ascertain the origin of the various energy levels.



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The Tunnel Diode Pair

D. J. HAMILTON M. J. MORGAN

A study of the volt-ampere characteristic of the two-tunnel-diode pair, or twin circuit, brings into focus the advantages of the circuit over the single tunnel diode. The V-I characteristic provides the designer with valuable information concerning the effects of varying the voltage of the sources supplying the bias voltage for the pair; the effects of internal resistance of the supply sources; the design of diode-pair circuits to perform majority logic; the design of diode-pair circuits for astable, monostable, and bistable multivibrator operation; the trigger requirements of multivibrator circuits; and the effects of loading upon multivibrator circuits.

IN THE APPLICATION OF TUNNEL DIODES to digital computers, a two-diode circuit called a pair, or twin, has been found to be useful as a basis for both logic and multivibrator circuits. Because the pair is a three-terminal network, one expects that it will be more interesting and perhaps more useful than the single tunnel diode. Since the pair is a network of active, nonlinear elements, for large signal applications it is convenient to construct a volt-ampere characteristic and make use of it to determine the performance of the pair.

The composite *V-I* characteristic of the pair is easily derived from the V-I characteristics of the individual diodes; a study of the composite characteristic reveals that the pair does indeed possess several advantageous features not common to the individual diodes. The composite characteristic provides a convenient demonstration of the effects of supply voltage and resistance upon the performance of the pair and leads to an understanding of the design and operation of logic and multivibrator circuits.

The V-I Characteristic of the Pair

The tunnel-diode pair circuit is formed by connecting two tunnel diodes and a supply source as shown in Fig. 1a. The supply source may be a d-c voltage, or a pulsed or sinusoidal voltage. The internal resistance of the supply is for the present assumed to be zero; effects of non-zero source resistance will be considered later.

It will be convenient to discuss the *V-I* characteristic of terminals *ab* of the pair shown in Fig. 2; this characteristic is derived from the individual diode characteristics. It is assumed that the diodes are identical, and the pair is split as shown in Fig. 3a. We may write two loops equations for Fig. 3a to determine that:

$$V_{db} = \frac{-V_s}{2} + V(I_1)$$

and

$$V_{cb} = \frac{V_s}{2} - V(I_2).$$

These two characteristics are shown in Fig. 3b.

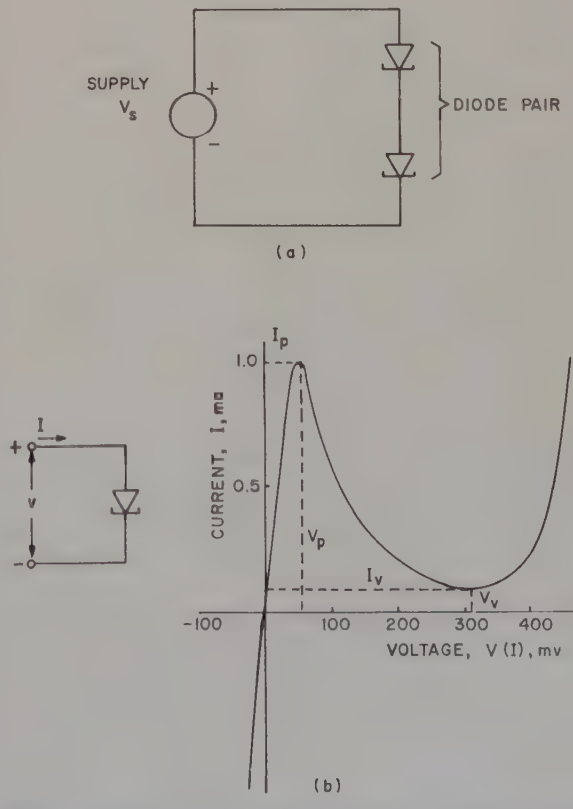

Fig. 1—Diode pair circuit with V-I characteristic of individual diodes.

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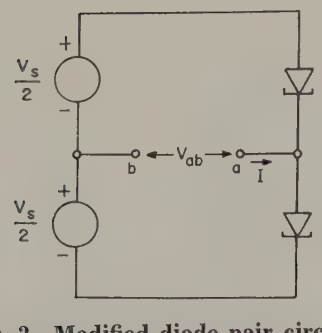
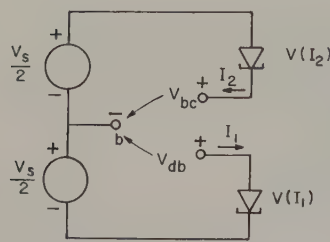


Fig. 2—Modified diode pair circuit.



(a)

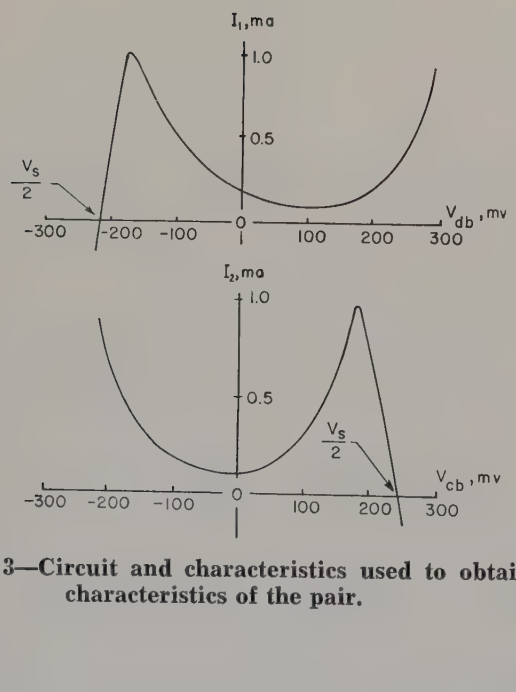


Fig. 3—Circuit and characteristics used to obtain V-I characteristics of the pair.

When terminals c and d are connected together to form terminal a, $V_{ab} = V_{cb} = V_{db}$ and $I = I_1 - I_2$. Thus the pair characteristic is formed by plotting the difference $(I_1 - I_2)$ as a function of V_{ab}; a sketch of a typical plot is shown in Fig. 4.

It will be noted that the pair characteristic is similar in shape to the individual diode characteristics: it has a region of negative conductance bounded by two regions of positive conductance, and the current is a single-valued function of the voltage. This similarity of characteristics suggests that the pair will be able to perform any function which can be performed by the single diode.

Further consideration of the method by which the composite characteristic was obtained reveals that the pair possesses several advantageous properties not shared by the single diode:

1. The *V-I* characteristic may be changed by varying the supply voltage V_s.
2. A value of supply voltage can be chosen so that the characteristic in *both* regions of positive conductance is controlled primarily by the *tunneling* characteristics of the individual diodes.
3. The *V-I* characteristic has odd-function symmetry, i.e., $I(V_{ab}) = -I(-V_{ab})$.

All of these properties are important in the use of the pair in logic and multivibrator circuits. The first and third properties can be deduced from inspection of Fig. 3b; the second deserves further comment.

For a single tunnel diode, the characteristic in the high-voltage region is highly dependent upon temperature. For $V > V_v$, the current is given approximately by:

$$I = I_v \exp [q\ (V - V_v)/kT]$$

where I_v is the tunnel diode valley current and is itself an exponential function of temperature. On the other hand, in the region $0 < V < V_v$, the characteristic is determined primarily by the tunneling properties of the diode and is reasonably independent of temperature. By choosing $V_s = V_v + V_p$ for the pair, we can take advantage of the tunneling properties of each diode while minimizing its thermal properties. This choice of supply voltage causes the current peak for terminals db to occur at a voltage for which the current through terminals cb is $(+I_v)$; very nearly zero. In this region the slope of the characteristic of terminals cb is very small for a broad range of voltages. Thus the characteristic in this region is determined primarily by the tunneling characteristic of terminals db. Furthermore, when $V_s = V_v + V_p$ the peak current I'_p of the pair is $I'_p = I_p - I_v$, the maximum value which I'_p can have. Small changes in V_s will change the voltage at which I'_p occurs, but will not materially alter the value of I'_p.

The three parameters of interest for the pair characteristic (I'_p, V_a and V_1) can be calculated in terms of the parameters of the individual diodes. If we assume that the supply voltage has been chosen to be $V_s = V_v + V_p$, we have demonstrated that the peak current is:

$$I'_p = I_p - I_v$$

By inspection we note that:

$$V_a = V_s/2 - V_p.$$

To calculate V_1, we first assume that the current I_1 in Fig. 3b through terminals db is

$$I_1 = I_v \exp [q\ (V_1 + V_s/2 - V_v)/kT]$$

where q is the electronic charge, k is Boltzmann's

constant, and T is the temperature in degrees Kelvin, when $V_{db} = V_1$.

Next we assume that the characteristic of the individual tunnel diodes is linear in the low-voltage region, so that the current through terminals *cb* is $I_2 = (I_p/V_p)\ (V_s/2 - V_1)$ when $V_{cb} = V_1$. Since V_1 is the voltage for which the current into the pair is zero, I_1 and I_2 must at that voltage be equal. Thus the transcendental equation to be solved for V_1 is

$$I_v \exp\left[q(V_1 + V_s/2 - V_v)/kT\right] = \frac{I_p}{V_p}\ (V_s/2 - V_1)$$

For the General Electric 1N2939 diode with

$I_p = 1$ ma., $V_p = 0.055$ volt,
$I_v = 0.1$ ma., $V_v = 0.350$ volt,

we obtain the following values:

$I_p' = 0.9$ ma.
$V_s = 0.405$ volt
$V_a = 0.148$ volt
$V_1 = 0.182$ volt

Supply Voltage Variations

We have shown that the supply voltage is an important factor in determining the *V-I* characteristic of the pair. One may think of the pair circuit of Fig. 2 as a nonlinear active two-port network, in which the supply voltage is connected to port 1 and the volt-ampere behavior of port 2—the terminals *ab*—is observed. As the supply voltage is varied a family of characteristics for terminals *ab* is obtained. A study of such a family, three curves of which are shown in Fig. 5, reveals interesting information regarding several approximate ranges of supply voltage:

1. When $0 < V_s < 2V_p$, *no* negative conductance region appears in the *V-I* characteristic of the pair.
2. For $2V_p < V_s < 2V_v$ the *V-I* characteristic exhibits a negative conductance region. Furthermore, when $V_s = V_v + V_p$ the value of the peak current of the pair is maximum.
3. When V_s is larger than approximately $2V_v$, no negative conductance region appears in the *V-I* characteristic.

We shall later see that this variation of *V-I* characteristic with supply voltage can be employed to advantage in both logic and multivibrator circuits.

Effects of Resistance

In the practical case, the supply voltage sources may have internal resistance as shown in Fig. 6, or there may be resistance in series with the pair, as in Fig. 7, or both. One would like to obtain a simple characteristization of the behavior at terminals *ab* in Figs. 6 and 7 in terms of the *V-I* characteristic of the idealized pair. It can be shown that it is not possible to obtain such a simple equivalent representation for Fig. 6 for all conditions of bias voltage and source resistance. However, if one considers only

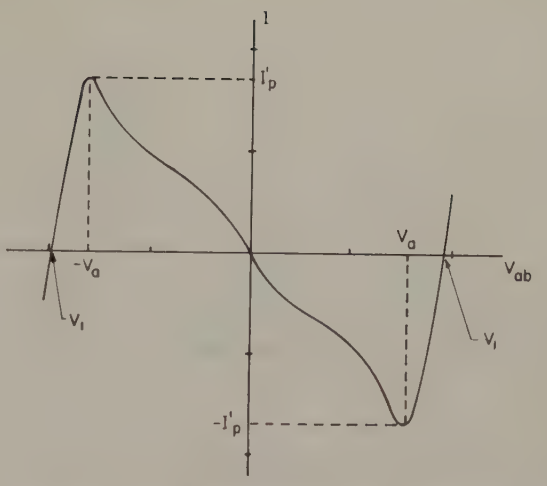


Fig. 4—Typical V-I characteristic of a diode pair with matched diodes.

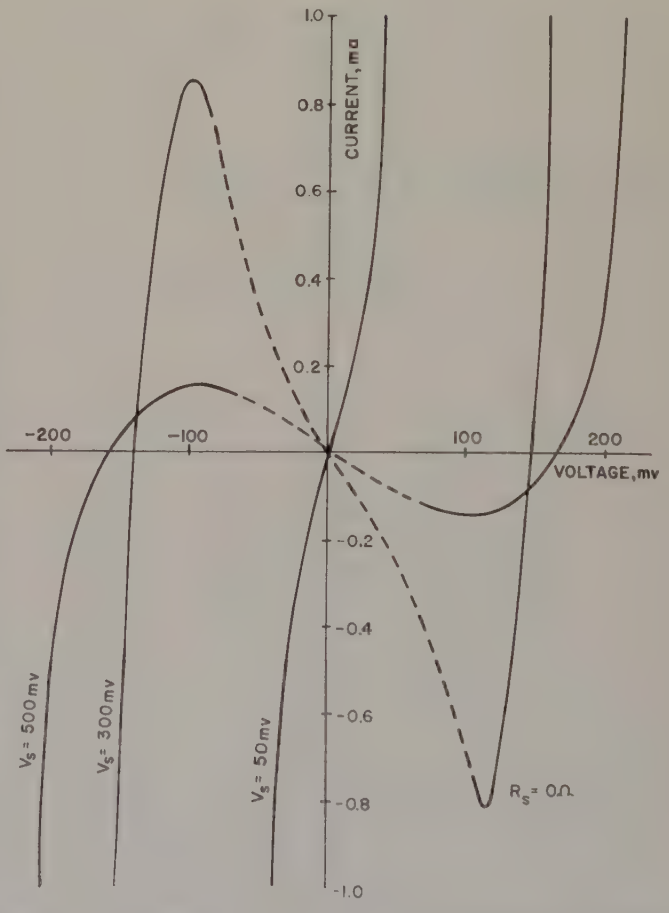


Fig. 5—Variation of the pair characteristic with supply voltage.

source resistances $R < V_p/I_p$ and bias voltage $V_s \cong V_v + V_p$, it can be shown that the behavior at terminals *ab* in Fig. 7 represents a very good approximation to the behavior at terminals *ab* in Fig. 6. We shall thus confine our attention to the case for which there is resistance in series with terminals *ab* as shown in Fig. 7. We may now make several gen-

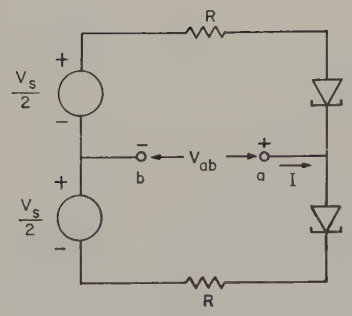


Fig. 6—Source resistance for balanced sources.

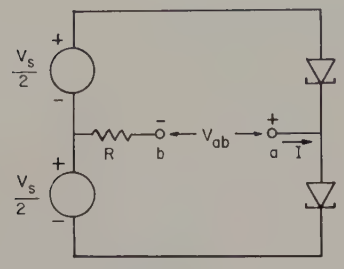


Fig. 7—Equivalent circuit for the pair with balanced sources having resistance.

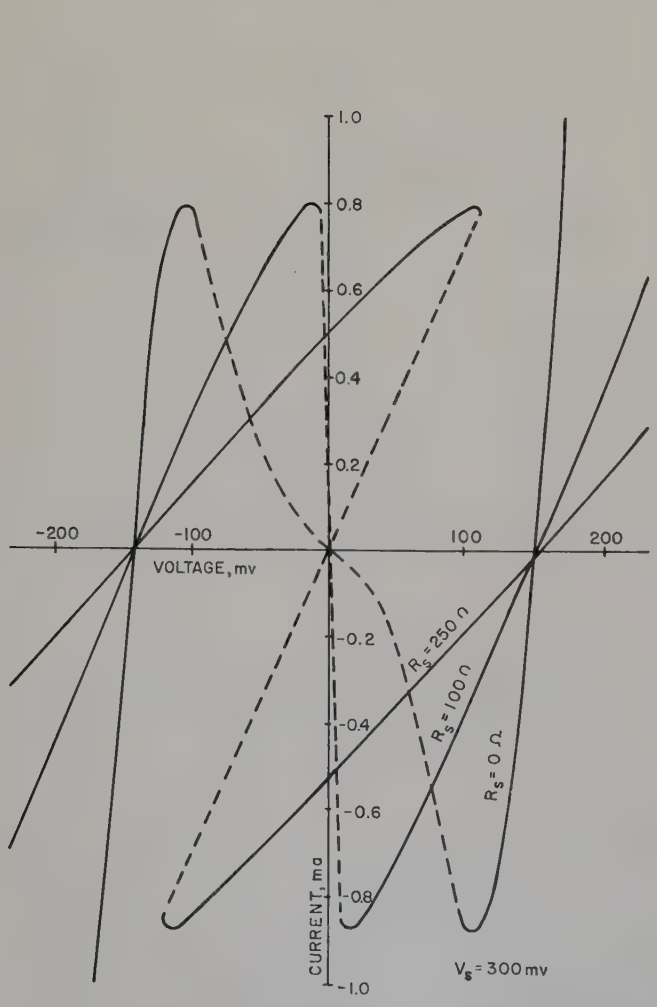


Fig. 8—Effects of source resistance on the V-I characteristic.

eral observations about the *V-I* characteristic in the presence of R. Suppose we assume that zero current flows through terminals ab. There will be no voltage produced across R and therefore the voltage V_{ab} will be the same as for the case $R = 0$, regardless of the value of R. For the case $R = 0$ we have seen that there are three possible values for V_{ab} when $I = 0$: $V_{ab} = 0$, $V_{ab} = +V_1$, $V_{ab} = -V_1$. These values remain unchanged as R is varied.

It can also be shown that the value of the peak current I_p' for the *V-I* characteristic of terminals ab remains the same, regardless of the value of R. The voltages at which $I = \pm I_p'$, however, are changed. The voltage at which $I = I_p'$ is $V = -V_a + I_p' R$ while the voltage at which $I = -I_p'$ is $V = V_a - I_p' R$. Thus as R is varied we obtain a family of curves such as that shown in Fig. 8. For most applications the presence of R is undesirable. Ideally one wishes to have infinite conductance in the positive conductance region so that the pair appears to be a voltage source whose polarity is positive or negative depending upon the state of the individual diodes. As long as the magnitude of the current is less than I_p', the voltage at terminals ab would remain fixed.

In the practical case, when $R = 0$, the conductance in the positive conductance region is moderately high and a change of current of I_p' produces about a 30 millivolt change in voltage. As R is increased, the same change in current produces a much larger change in voltage, and the characteristic becomes more "sloppy." If R is made large enough, the negative conductance region of the characteristic disappears, as Fig. 8 demonstrates. Thus increasing R represents an increasing departure from the ideal case.

A Logic Application

The tunnel diode pair has been used by Goto to perform logic operations.[1] The basic circuit is shown in Fig. 9; this type of logic circuit uses a pulsed supply source and performs *majority logic* as follows. It is assumed that all inputs come from other diode pairs. A logical "1" state is defined as existing when V_{ab} is positive and in the positive conductance region. A "0" state exists when V_{ab} is negative and in the positive conductance region. We assume that initially the clock voltage is zero for the particular pair under consideration. All of the inputs which come from pairs in the "1" state will cause a current to flow into terminal a, and the inputs which come from pairs in the "0" state cause a current to flow out of terminal a. The net current at terminal a will thus have a direction corresponding to that of the *majority of* the inputs.

For example, suppose that the majority of the inputs favored the "1" state, and a net current is flowing into terminal a. If the clock is now turned on, the *V-I* characteristic begins to take shape as previously described. The current into terminal a, although it

may be very small, forces V_{ab} to be positive. When a negative conductance region begins to appear in the characteristic, all input currents could be reduced to zero and the state of the pair would remain that which the majority of inputs had been. Thus, once a negative conductance appears in the characteristic the pair is "locked" in the majority state. As soon as the pair is locked, the clock serving all the input pairs may be removed since the majority information is stored in the pair under consideration as shown in Fig. 9. Output lines may be taken from terminal *a* to drive other pairs served by still another clock.

Based on our previous discussion of the pair, we may make several general remarks concerning the pair as a logic circuit. First, the variation of the V-I characteristic of the pair with supply voltage is an essential feature of the operation of the majority logic circuit. Because of this capability, only a small net majority current is needed to "prejudice" the pair as its clock source is turned on.

Second, high positive conductance of the characteristic is necessary in the pairs supplying the inputs so that their voltages, and hence the input currents, do not exhibit much variation with the number of inputs a pair must supply.

Third, odd-function symmetry of the pair is essential so that the voltages, and hence the input currents, produced by pairs in the "0" state will be opposite in direction but very nearly equal in magnitude to those produced by pairs in the "1" state.

These last two features are necessary if a majority of only one in the input lines is to be capable of producing a net current in the proper direction to "prejudice" the pair toward the majority state. From our discussion of the effects of resistance we conclude that for optimum performance the supply source resistance should be as nearly equal to zero as is possible. We also note that any unbalance between the diodes of the pair will tend to destroy the odd-function symmetry of the characteristic, thereby making the currents produced in the "1" state different from those produced in the "0" state. Hence a single majority may not be sufficient for correct operation.

Finally, the *V-I* characteristic of the pair helps to visualize its operation and design in a logic circuit. Once the supply voltage has reached its maximum value and the supplies have been removed from all other pairs connected to the pair under consideration, all input and output lines appear approximately to be conductances of value $G=1/R_s$ connected to terminals *ab*. This is shown graphically in Fig. 10 where the slope of the "load-line" is the negative of the sum of all the *G*'s connected to terminal *a*. For unambiguous operation we note from Fig. 10 that the total conductance must be less than I_p'/V_a. Since all the conductances are equal, this imposes a maximum on the conductances for a given number of inputs and outputs. The minimum value of conductance can be determined by a "worst-case" analysis which takes into account the tolerance variations of R_s and the parameters of the *V-I* characteristic, as well as the voltage variation resulting from the finite slope of the characteristic.

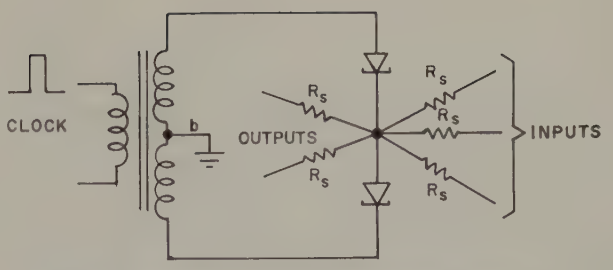


Fig. 9—The Goto majority logic circuit.

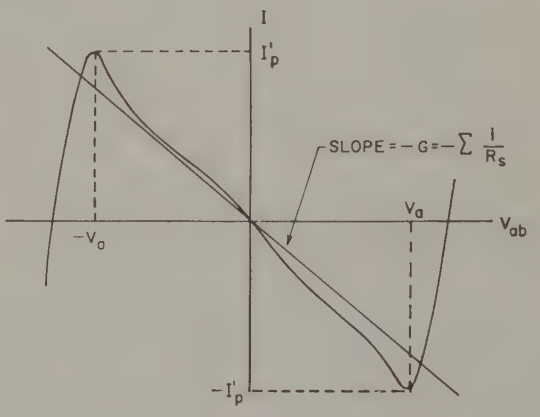


Fig. 10—Use of the V-I characteristic to determine total input and output conductance.

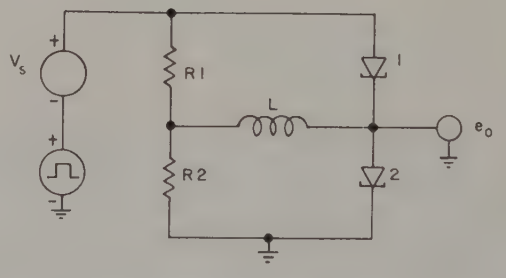


Fig. 11—Multivibrator with voltage trigger.

Multivibrator

In general for multivibrator action, a circuit must exhibit a negative conductance at some terminal pair to cause regeneration, and an energy storage element to maintain the proper switching sequence. In the case of the circuit in Fig. 11, the diode pair provides a region of negative conductance, and the inductor furnishes the energy storage. The inductively-coupled multivibrator of Fig. 11 will be used to further illustrate the usefulness of the diode pair V-I characteristic in the multivibrator design.

There are three possible modes of operation for the

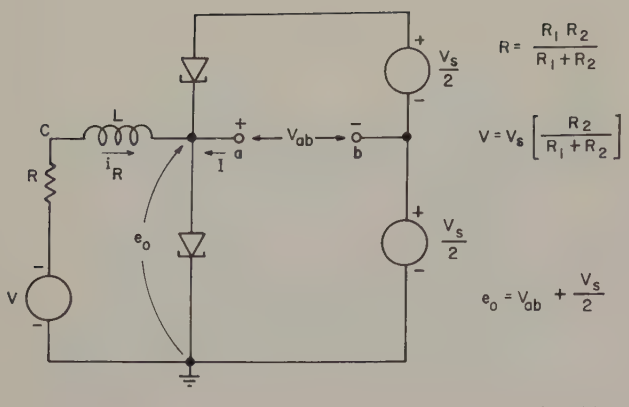


Fig. 12—Circuit model for multivibrator of Fig. 11.

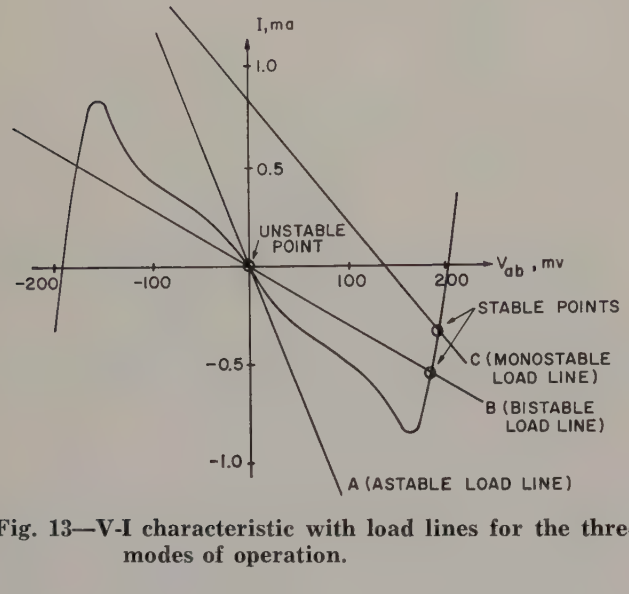


Fig. 13—V-I characteristic with load lines for the three modes of operation.

circuit: astable, bistable, and monostable. With the assistance of the V-I characteristic for diode pair and the equivalent circuit of Fig. 12, one can design the multivibrator for the type of operation desired. In the equivalent circuit it is of interest to note that if R_1 and R_2 are equal, the voltage V_{ab} is zero since the equivalent voltage, V, is $V_s/2$. Thus the equivalent resistance R appears to be connected to terminals a-b, and the load line will pass through the origin of the V_{ab}-I characteristic.

The procedure for designing a multivibrator circuit is straightforward. One selects a reasonably well-matched pair of tunnel diodes and chooses a value of supply voltage to obtain the desired V-I characteristic (normally $V_s = V_v + V_p$). Then R_1 and R_2 are chosen to produce a load line which intersects the characteristic at the proper points for the desired mode of operation. For astable operation, the load line must intersect the V-I characteristic at *only* one point, and the single point of intersection *must* be in the negative conductance region. This can be accomplished by making R_1 and R_2 equal and of value less than $2V_a/I_p'$. The astable mode is illustrated in Fig. 13 by line "A."

For the bistable mode the load line must intersect the characteristic at two points in the positive conductance regions; this is shown in Fig. 13 by line "B." Again $R_1 = R_2$ and $V_s = V_v + V_p$ are chosen, but R_1 and R_2 must be of value greater than $2V_a/I_p'$. The two stable states of the circuit are given by the points of intersection of the load line and the V-I characteristic in the positive conductance regions.

As is shown in Fig. 13 by line "C," the monostable mode requires that there be a single intersection of the load line and the characteristic and that the intersection be in *one* of the positive conductance regions. Unlike the other two modes the load line cannot pass through the origin of the characteristic if the diodes are matched, because the proper intersection with the V-I plot cannot be achieved. Therefore R_1 and R_2 must be unequal in order to provide the required offset of the load line. In addition, the values of R_1 and R_2 are chosen to produce the desired point of intersection which defines the single stable point of operation of the circuit.

When the multivibrator is loaded, one can gain some insight of the effect on its operation from V-I characteristic. A resistance load which is directly coupled to the output terminals adds another resistance in parallel with R_2; consequently the equivalent voltage, V, is changed. Thus both the slope and the position of the load line are changed, and the mode of operation of the circuit may be changed. The conclusion is that load resistance should be large in comparison with R_2. In the case of an a-c coupled load, its value should be large in comparison with R_2 due to its shunting of the output terminals.

The subject of triggering merits consideration because of its importance in the monostable and bistable modes. We shall assume the bistable mode for illustration of the use of the V-I characteristics in determining the trigger requirements. We shall also assume $R_1 = R_2$ so that the operating points of the circuit are as shown in Fig. 14a thus requiring that a current I_o is flowing in the inductor. As will be shown, there are two possible methods of triggering the multivibrator of Fig. 11, current or voltage triggering. Current triggering is the most straight-forward of the two methods because all that is required is to inject into terminal a a current greater than $(I_p' - I_o)$; since the current in the inductor will not change during the trigger, the total current into terminal "a" will exceed I_p', and the operating point will be forced into the other region of positive conductance. Voltage triggering is more interesting because it takes advantage of the variations of the V-I characteristic with supply voltage. As has been previously demonstrated in Fig. 5, the peak value, I_p', of the V-I characteristic can be varied by changing the supply voltage. It will also be noted that I_p' will decrease for either positive or negative variations of V_s in the region of $V_s = V_v + V_p$. Therefore by adding a positive or negative trigger voltage in series with the supply, assuming $V_s = V_v + V_p$, the peak current of the V-I characteristic can be decreased. If the trigger

s of sufficient amplitude, the peak of the characteristic, I_p', will fall below the value of I_o, as shown in Fig. 14. Since the inductor maintains the current I_o into terminal "a," the operating point will switch into the other positive conductance region. As a result of the knowledge of the effect of voltage variations on the *V-I* characteristic, one can determine the approximate magnitude of trigger required by adjusting the supply voltage until I_p' becomes less than I_o; the difference between this voltage and the *d-c* operating voltage is the required trigger magnitude. (Note that slightly different magnitudes of positive and negative triggers will be required). When the trigger is removed, the current in the inductor changes slowly and the operating point relaxes to the stable point $I=I_o$ as shown in Fig. 14.

Curve Tracer

In order to verify the theoretical results discussed previously and to permit the study of the effects of unbalances in the diode pair circuit, the curve tracer of Fig. 15 was designed. Because of the desirability of using an X-Y plotter in obtaining a record of the characteristic curves, a scheme involving a manual sweep was chosen. R_{11} provides the necessary sweep voltage, which can be varied by manually adjusting the potentiometer. R_9 and R_{10} limit the range of the sweep voltage. Resistors R_1 and R_2 provide a coarse and fine adjustment of the supply voltage, V_s, for the pair. The effective source resistance is furnished by R_5 which is the same as R in Fig. 7. To make possible the study of unbalances in supply voltage, S_1 and R_8 are included. Unbalance of source resistance is obtained by opening S_2 and S_3. The output quantities are two voltages: V_{ab} is measured directly, but the current, I, is measured by developing a voltage across R_{12} proportional to I.

All of the curves shown in Fig. 5 and 8 were made with the curve tracer circuit of Fig. 15. The broken-line portions of the curves are extrapolated points. The extrapolation is necessary because of spurious results caused by oscillation of the diodes in the negative conductance region. To overcome the problem of oscillations, one must keep the circuit impedance as low as possible.

Acknowledgement

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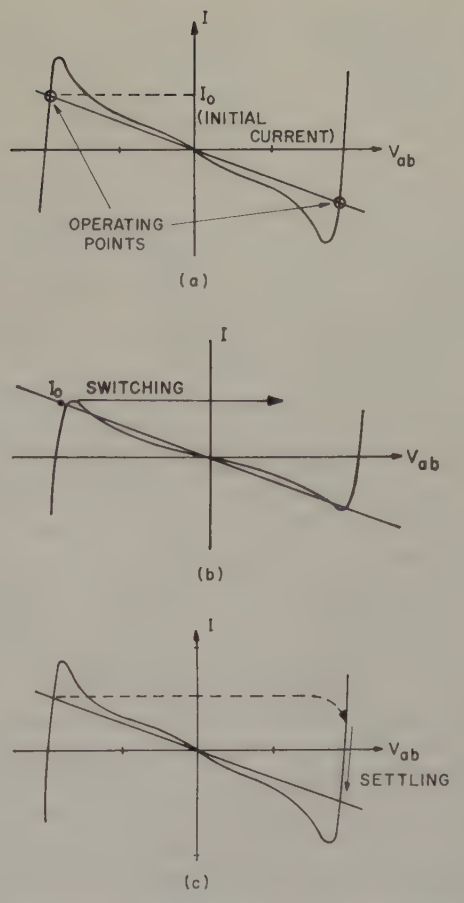

Fig. 14—Operating point trajectory for triggered bistable circuit.

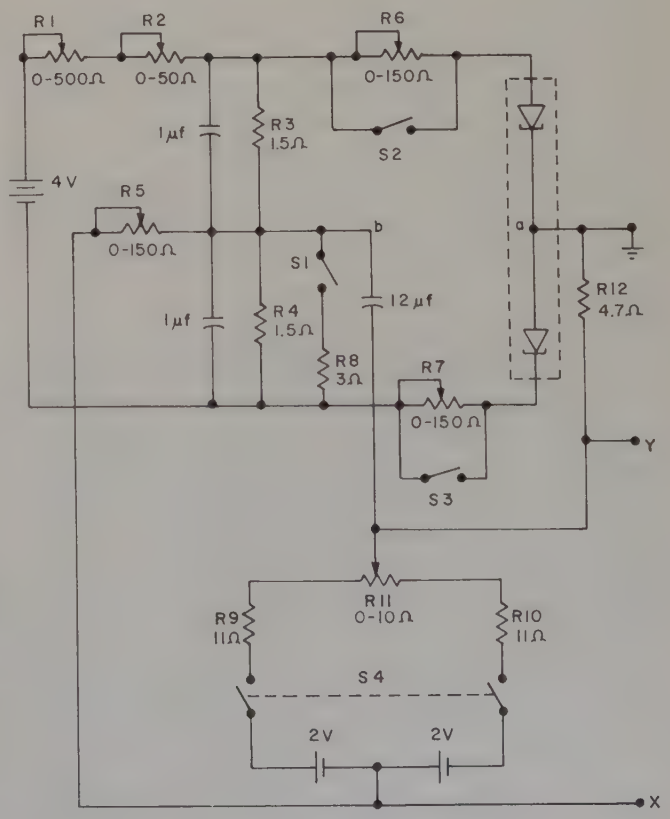

Fig. 15—Circuit diagram for the diode pair curve tracer.

An Introduction To The Avalanche Transistor

C. D. ROOT* E. ADLER*

THE AVALANCHE MODE type of operation of transistors has been known for some time and a number of articles[1-5] on this subject have appeared in the literature in the past few years. However little advantage could be taken from such operation since only recently have suitable transistors become available. This came about as the result of improvements in manufacturing technology (leading to, for example, the reduction of surface leakage currents) which enabled units capable of operating continuously and reliably at the high voltages involved to be produced. For example, silicon alloy units are now available which have high switching speed, (typically of the order of one or two nano-seconds) and high power handling capability (the rated dissipations being 50 watts peak and 250 milliwatts mean). These properties suggest that this type of transistor may find progressively wider fields of application, one obvious use being in the next generation computer.

Exploratory work is presently being carried out to improve the operation of these transistors and to solve the problems associated with their incorporation in equipments. In the following a detailed description of the processes taking place inside the transistor is given, the operation of some simple circuits incorporating the avalanche transistor is explained, and some aspects of its negative resistance property are briefly outlined.

In order to describe the avalanche mode operation of a transistor it is first necessary to describe the collector breakdown characteristics of the common base (BV_{CBO}) and common emitter (BV_{CEO}) configurations. This must be done because avalanche mode switching is nothing more than a rapid transition from common base type breakdown to the common emitter type.

Common Base Breakdown

Collector breakdown of a transistor in the common base configuration is breakdown of the collector to base diode. While such breakdown can be due to a Zener process or surface effects, the most usual cause, and that which must be the cause for avalanche mode operation, is carrier multiplication within the space charge region of the reverse biased diode.

This type of breakdown occurs because current carriers crossing the space charge region do so under the effects of an electric field. The carriers interact with the crystal lattice, and in so doing give up energy which can cause the creation of hole-electron pairs. As the applied voltage is increased, the electric field becomes stronger so that the carriers acquire more energy between interactions and can thus generate more hole-electron pairs upon interaction. The holes and electrons which are created travel out of the space charge region in opposite directions and each pair therefore constitutes a carrier crossing the entire region. The theoretical limit to this occurs when each carrier crossing the entire region has a probility of unity of creating a hole-electron pair. (This is a slight simplification since holes and electrons have different properties regarding the generation of hole-electron pairs, but the statement is essentially correct.) The breakdown leads to voltage-current characteristics of the type shown in Fig. 1.

In addition to causing collector breakdown, this carrier multiplication process has another important effect, namely on the current gain of the transistor. Consider the common base current gain α or h_{fb}, which may be considered to be made up of the four factors

$$\alpha = h_{fb} = \alpha^*\beta\gamma m \qquad (1)$$

Here α^* is the so called collector efficiency and usually has a value greater than unity; it will be considered to be exactly unity in this discussion. β is the transport factor and represents the fraction of the minority carriers injected into the base by the emitter which reach the collector, the balance being lost by recombination. γ is the emitter efficiency, which is defined as the fraction of the emitter current which is made up of minority carriers entering the base region. m is the multiplication rate of the collector space charge region.

The last mentioned effect is the same as that which causes the collector diode breakdown, and is included in the above equation because the hole-electron pairs created in the space charge region are swept out with electrons going to the n-type side and the holes going

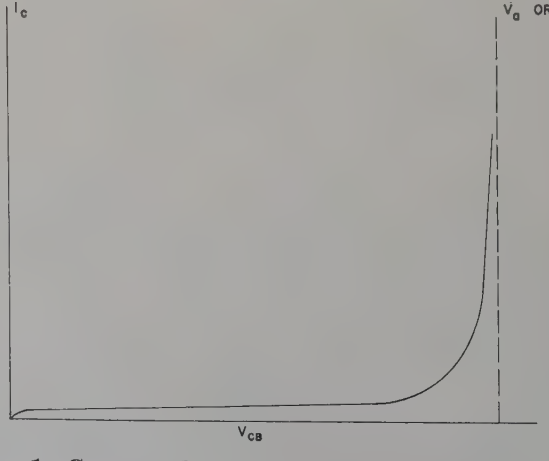

Fig. 1—Common base characteristic with emitter open.

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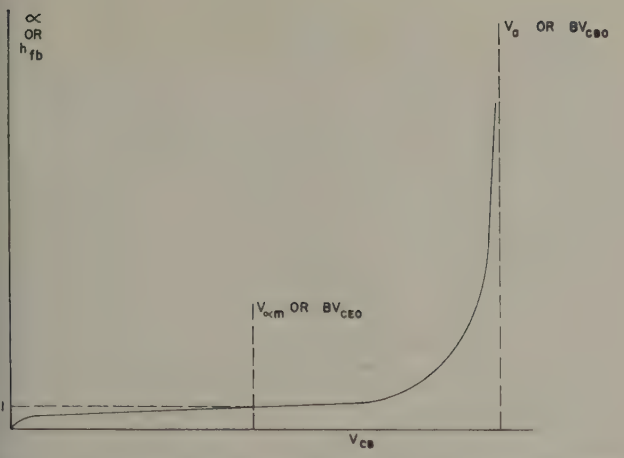


Fig. 2—Common base current gain vs. Collector voltage.

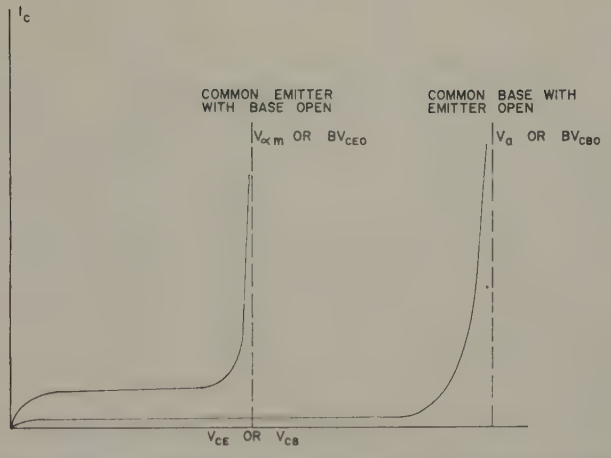


Fig. 3—Comparison of common base and common emitter breakdown.

to the p-type side. Since they are then majority carriers, those entering the base may make up for losses due to β (recombination) and γ (emitter efficiency). In other words, since these losses no longer need be made up by base lead current but are supplied by current crossing the collector junction, the gain is increased. If the transistor has values of β and γ of almost unity, only a small amount of multiplication is sufficient to increase h_{fb} to unity. The variation of h_{fb} with changes in collector voltage V_c is shown by the typical curve in Fig. 2. It may be noticed that this has the same general shape as that in Fig. 1; this is to be expected since both are governed mainly by m. The value of h_{fb} is unity at a collector voltage which is labelled V_{am} in Fig. 2; when the applied voltage is greater than this value, the gain exceeds unity.

Common Emitter Breakdown

Turning now to the common emitter configuration, the current gain for this is related to the common base current gain by the relation:

$$h_{fe} = \frac{\alpha}{1-\alpha} = \frac{h_{fb}}{1-h_{fb}} \qquad (2)$$

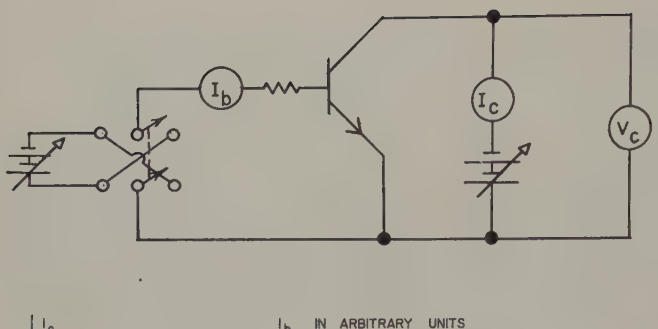
When the collector to base voltage is such that h_{fb} equals unity, h_{fe} becomes infinite and the collector may be considered as being in the break-down condition. A physical explanation of this phenomenon is that all losses of minority carriers from the emitter are replaced by the products of multiplication in the collector space charge region, the effect of this being the same as if all the collector current were made up of minority carriers injected from the emitter. However this leaves the collector still unsatisfied in its efforts to deplete the base of the normally present minority carriers, and so the collector current increases. Now an increase in collector current must be matched by an increase in emitter current (i.e. more carriers are injected into the base) and there still exists a condition where the collector has not depleted the normally present minority carriers. This process continues until the various circuit resistances account for sufficient voltage drops to result in a stable operating point. A comparison between the current-voltage characteristics for the common base and the common emitter configurations, the latter having open circuited base lead, is given in Fig. 3. The current level for the common emitter case is higher throughout; this occurs because the minority carriers which reach the collector from the emitter are in excess of the normal reverse current ($m\ I_s$). It can be shown that its value is:

$$I_c = mI_s\ (h_{fe} + 1) \qquad (3)$$

Composite Characteristics

The next circuit to be considered is a common emitter configuration having a base supply capable of reversing polarity. This is shown in Fig. 4a, and Fig. 4b shows the static characteristics obtained. When the base current is applied in the conventional direction, normal emitter characteristics are obtained. However, when the base current is reversed, both diodes in the transistor operate in a reverse biased condition (assuming the collector voltage is not too high); the emitter is now not injecting minority carriers into the base and the collector characteristics are of the common base type.

If the reverse base current is larger than the collector current, then the emitter diode will be reverse biased since the current difference flows as a reverse emitter current. As more collector voltage is applied, the collector current increases. This increase will take up some of the base current and the emitter current will become smaller. Eventually a point is reached where the base to collector current flowing through the base resistance of the transistor is sufficiently large to forward bias a portion of the emitter. When this happens, the transistor reverts to the common emitter breakdown mechanism. If large reverse base currents are used, this does not occur until a collector voltage nearly equal to V_a is applied. For small reverse base currents, e.g. shown by the one unit reverse base current curve in Fig. 4, the collector volt-



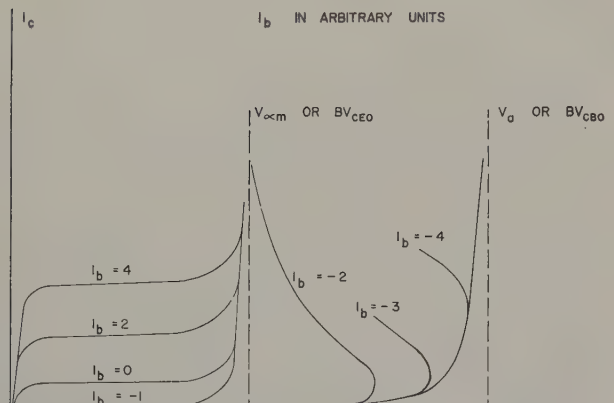


Fig. 4—(a) Common emitter circuit with reversible base current; (b) Composite characteristics.

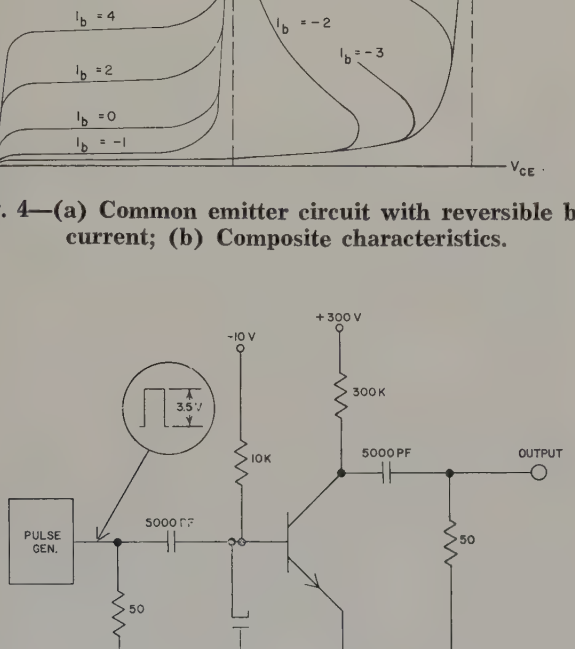


Fig. 5—Common emitter switch.

age may never exceed the normal common emitter breakdown voltage V_{cm}. The reason for this is that the current through the base resistance is sufficient to forward bias a portion of the emitter at the V_{am} voltage.

Switching Mechanism

When an avalanche transistor is arranged to operate as a switch, the most common practice is to apply a reverse base current sufficiently large to hold the entire emitter in a reverse biased condition, while a collector voltage almost equal to V_a is applied; in these circumstances the collector diode is operating in a condition of high multiplication. To initiate the switching process, the base current is suddenly changed from the reverse to the forward direction and the collector experiences an extremely rapid change to the V_{am} voltage. It is speed of this transition which makes this method of operation unique.

Shockley and Gibbons[6] have explained why this switching occurs so rapidly. Normally, the switching time is governed by the time the diffusing minority carriers take to reach the collector in large enough numbers to cause a specified change in collector current. The above authors point out that in avalanche mode operation the collector diode is in a condition of high multiplication before switching starts, and when the leading edge of the wave of diffusing minority carriers arrive (not enough to cause much change in the collector current) a large number of hole-electron pairs are generated. The carriers which are swept back into the base are majority carriers and these immediately require the presence of more minority carriers to maintain charge neutrality. The emitter therefore emits more minority carriers, and again it requires only a small portion of the leading edge of the diffusing carriers to cause large back injection of majority carriers. This process continues rapidly until very large emitter to collector currents flow. The high initial speed of the switching action is progressively reduced as the collector voltage approaches V_{am} because the multiplication drops sharply, but overall switching speeds are obtained which are very much greater than those to be expected from a normally operating transistor of comparable base width.

Pulse Amplifier

One basic application of the switching circuit described in the previous section is in an externally triggered switch or pulse amplifier. A typical common emitter circuit is shown in Fig. 5. The initial or *off* state of the transistor is, as mentioned previously, the condition where the emitter diode is reverse biased by the base bias circuit and the collector is allowed to attain the avalanche potential V_a via the 300 Kilohm resistor and the 300 volt supply. When a triggering pulse is applied to the base the transistor changes to the *on* state in the manner explained previously and the collector capacitor, charged to V_a during the *off* time, is discharged via the collector to emitter breakdown path and the 50 ohm output resistor. The extremely low series resistance of the discharge circuit allows high peak currents to flow, typically of the order of 1 ampere, so that an output pulse of 50 volts amplitude is available across the 50 ohm resistor. The collector to emitter breakdown only lasts so long as there is stored energy in the capacitor to sustain it since the alternative path (from the 300 volt supply via the 300 Kilohm resistor) is unable to supply sufficient current. After initiating the operation the base trigger potential must be removed so that the emitter diode may revert to the reverse biased condition and the collector circuit must be allowed time to recharge so as to be ready for a subsequent operation.

An emitter follower switch, a slight variation on the above circuit, is shown in Fig. 6. Here the only real difference is the position of the 50 ohm resistor in the output circuit; it is shown as the termination for the cable connecting the switch to the circuit to be fed from it and may typically constitute the input resistance of the latter. The practical difference between the two switch circuits is that the output from the common emitter switch is negative while that from the emitter follower is positive; in both cases the trigger input signal is positive.

The maximum pulse recurrence frequency at which the switch may operate is determined by the allowable mean dissipation of the transistor. This can be divided into four parts as follows:

a) The dissipation in the *off* state
b) The energy associated with the discharge of the collector capacitor during the switching time $(CV^2/2)$, averaged over the whole cycle
c) The dissipation in the *on* state
d) The dissipation during the relatively slow recovery from the *on* to the *off* state

The relative importance of these four factors contributing to the total dissipation will change as various circuits and different transistors, possibly made from different materials, are considered.

Oscillator

The circuit of Fig. 7 shows the basic switch connected in a self-exciting or relaxation oscillator circuit. The mechanism which initiates the switching is as explained in the section on composite characteristics. Thus, if the emitter is initially biased in the reverse direction, the current flowing from collector to base creates across the extrinsic base resistance a gradually increasing voltage which eventually becomes large enough to forward bias the emitter diode; thereupon the avalanche switching process takes place. When the collector capacitor has been discharged, i.e. the *on* condition can no longer be maintained, the emitter diode ceases to conduct and the circuit gradually reverts to the original condition whereupon a repetition of the cycle ensues.

The maximum obtainable operating frequency is again set by power dissipation considerations. Of the four previously mentioned parts contributing to this, (a) and (c) can in this application be neglected, and it is assumed that (d) is also negligibly small (true for the 2N1468 transistor). In that case the energy associated with the capacitor discharge $CV^2/2$ must be averaged over the period T of the oscillation. Since the capacitor discharge time is much smaller than the recharge time, it may be assumed that the latter is equal to T so that

$$T = C\,R_c \log_e V_{cc}/(V_{cc} - V_a)$$

where V_{cc} and V_a are the supply and transistor avalanche voltages respectively and C and R_c represent the collector capacitor and resistor respectively. Using the above expression for T, the mean dissipation

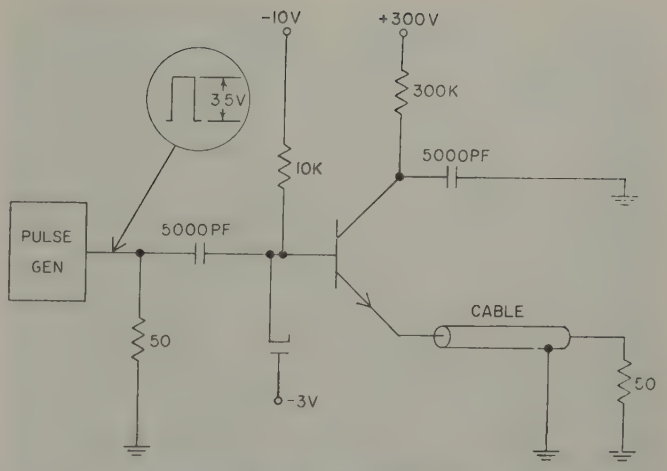


Fig. 6—Emitter follower switch.

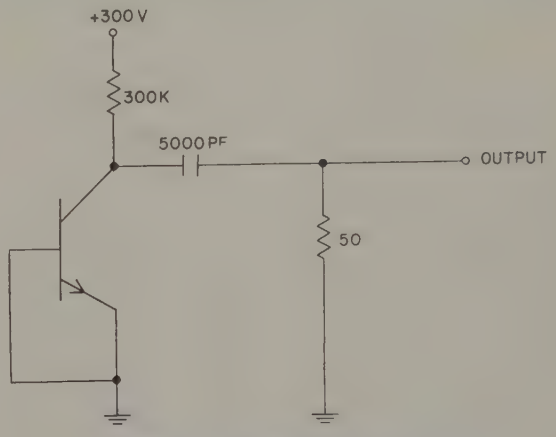


Fig. 7—Oscillator circuit.

$p = CV^2_a/2T$ becomes:

$$p = V_a^2/2R_c \log_e [V_{cc}/(V_{cc} - V_a)]$$

which is independent of the value of C.

Punch-Through Oscillator

The punch-through oscillator operates in a basically similar manner to the avalanche mode oscillator described above, but relies instead on the punch-through effect. This effect, which in general is considered undesirable, occurs when the collector is biased to the punch-through voltage V_p; this results in such a wide collector depletion layer that it stretches right through the base to the emitter, thus collapsing the potential barrier of the emitter and allowing minority carriers to flow into the space charge region. The effect disappears when the collector bias is removed and does not cause permanent damage to the transistor. As already stated, an oscillator based on this effect can be made to operate in a manner very similar to that described in the preceding section provided that, for the transistor used, $V_p < V_a$.

Measurement Of Switching Speed

The rapid switching speeds encountered with the type of circuit described requires the use of special oscilloscopes since the bandwidth of those generally

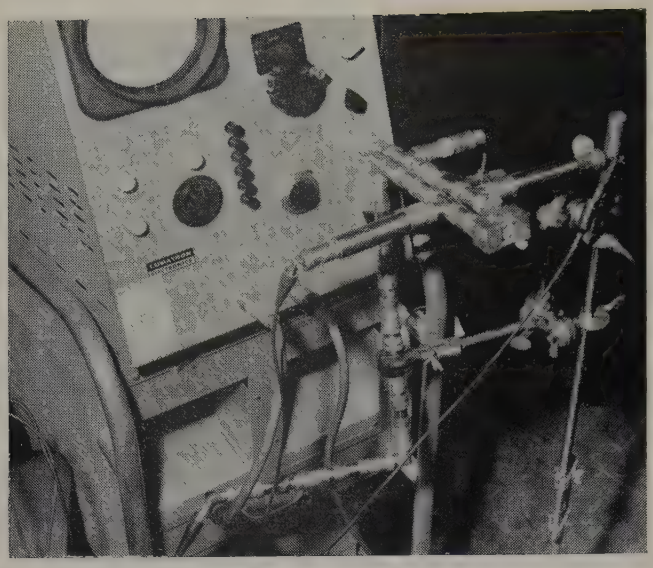


Fig. 8—Mechanical layout of circuit of Fig. 5.

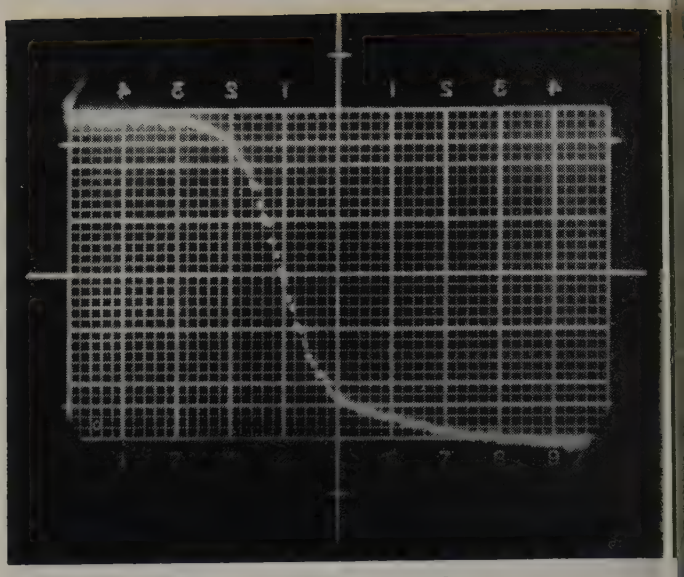


Fig. 9—Switching waveform.

encountered is insufficient to give true displays of the associated waveforms. A number of sampling and other types of oscilloscopes have recently become available, and these may typically have rise-times of the order of 0.4 nanosecond. In addition great care must be taken with the mechanical layout of the circuits and the use of coaxial lines and components has been found beneficial. Fig. 8 is a photograph of the circuit of Fig. 5 laid out using coaxial components and Fig. 9 shows the switching waveform displayed on the oscilloscope; in this figure the horizontal scale is 1 nanosecond per centimeter and the height of the pulse is 70 volts. It may be seen that the rise-time of this transistor, which is usually measured between the 10 and 90 percentile points, is approximately two nanoseconds.

Negative Resistance

The switching performance of the avalanche mode transistor intuitively suggests that its characteristics include a negative resistance portion, and Fig. 4 shows that under certain biasing conditions a negative resistance may be obtained. The "S" shape of the curves show that this negative resistance is current controlled, i.e. the collector voltage is a single valued function of collector current. When comparing this property with those of the tunnel diode, it should be remembered that the latter has an "N" shaped curve yielding a voltage controlled negative resistance. It appears that little has been done to date to exploit this property of the avalanche mode transistor; it may be expected that an avalanche mode transistor negative resistance amplifier will be noisier than one employing a tunnel diode because the d-c bias currents involved have larger magnitudes and the multiplication process at the collector junction may add a noise component to the output signal.

Applications

It is to be expected that it is the switching property based on the avalanche effect (rather than the punch-through effect or the negative resistance) that will receive most attention in the future. An obvious application of the transistor is in a pulse generator. Already it is possible to generate pulses having 50 volts amplitude and nanosecond rise and fall-times available from a generator impedance of 50 ohms and at a repetition rate of 50 to 100 kilocycle per second. It is probably not too optimistic to predict that advances in manufacturing technology and encapsulation of the transistor in coaxial packages or strip transmission line components will enable this performance to be improved to megacycle repetition rates and fractional nanosecond rise and fall-times.

A potentially much wider field of application of the transistor is in computers of the future, operating with clock rates of tens of megacycles. The fast rise-times of the avalanche transistor and the ability to control recovery time both with transistor design and external circuitry as well as the low manufacturing cost of fusion alloy transistors make the future extremely bright.

Acknowledgments

The authors are indebted to R. C. Wonson for many useful discussions relating to the subject matter of this article.

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Gold Alloying to Germanium, Silicon and Aluminum-Silicon Eutectic Surfaces†

L. BERNSTEIN*

Part 1

The results of separate studies of large and small area bonds to germanium and silicon surfaces are discussed. Metallurgy and choice of backing material to avoid cracking are described. Compositions of gold-tin offer the most versatile bonds in a variety of atmospheres. Electrode attachments to the aluminum-silicon eutectic regions in semiconductor devices, by means of gold or gold alloys, often produce a condition referred to as the "purple plague" (the $AuAl_2$ phase formation) with subsequent mechanical failure. Conditions which promote its formation in addition to the more desirable Au_2Al phase are discussed. Wetting and surface tension problems associated with attachments to the Al-Si surface via Au-Sn, Au-Ge and Au-Si alloys are described in connection with the gold-aluminum compound formation. Typical photomicrographs and thermal expansion curves for the systems involved are presented herein.

OF ALL THE COMMON TECHNIQUES for making electrode attachments in fabricating semiconductor devices (pressure, evaporated films, electroplating, thermocompression bonding, and alloying) the alloy fusion technique, where feasible, is the most satisfactory method for obtaining an intimate and permanent contact.

In device processing, corrosive acids are often used to etch p-n junctions to improve electrical properties. Alloying materials with good corrosion resistance therefore are not only desirable, but at times necessary. Gold meets this requirement quite well. The melting points of gold eutectics with germanium and silicon (356° and 370°C, respectively) are high enough to provide adequate device stability, yet low enough to provide ease of fabrication. In addition, they contain sufficient quantities of gold (88 and 94 wt %, respectively) to provide good etch resistance.

A common practice in producing p-n junctions in silicon is to alloy aluminum onto an n-type silicon surface. Upon cooling, the end product is the aluminum-silicon eutectic. General experience at the Hughes Semiconductor Division has been that devices made by attaching a gold or gold-alloy electrode to the eutectic, have occasionally shown mechanical failures concurrent with the appearance of a brittle, porous, and purple phase. It is the purpose of this study to record the results of some investigations into alloys which may prove useful in electrode attachments, and also to determine the nature of this purple phase. The study deals with the problems in alloying gold to germanium and silicon surfaces with emphasis on cracking due to thermal mismatch and the problem of initiation of wetting.

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*Now with Alloys Unlimited, Inc. A portion of this work was done by the author while with Hughes Semiconductor Products.

Alloying to Silicon and Germanium Surfaces

Although there has been much published data on the less noble metal contacts to silicon and germanium, a literature search produced very little on gold alloying. Taylor[1,2,3] concerned himself primarily with conditions under which semiconductor surfaces are cracked during fabrications. Sullivan[4] and Eigler discuss the hydriding technique for alloying onto silicon. Henkels[5] presents a generalized usage of germanium and silicon contact solders. Peterson[6] and co-workers, and Jenny,[7] studied lead alloying onto germanium. Indium alloying onto germanium surfaces was investigated by Thomas and Dacey,[8] Goldstein,[9] Mueller,[10] Pankove,[11] and Rose.[12] Lead-tin and aluminum-indium alloying for "thyristor" fabrication was discussed by Mueller and Hilibrand.[13] Gudmundsen[14] and co-workers studied tin-alloying to silicon using a flux. In addition, they discussed the problems associated with gold alloyed to silicon surfaces. Aluminum contacts to silicon were investigated by Prince,[15] Gudmundsen and Maserjian,[16] and Wannlund and Waters.[17]

Electrode attachments were divided into two groups —those in which contacts were relatively small in area compared to the Si or Ge surface, and those in which the semiconductor was fused to a clad substrate larger in area than its surface. The former are referred to as small area contacts, the latter as large area contacts. The silicon or germanium dice used in this study were .100 x .100 x .020 before etching or cleaning.

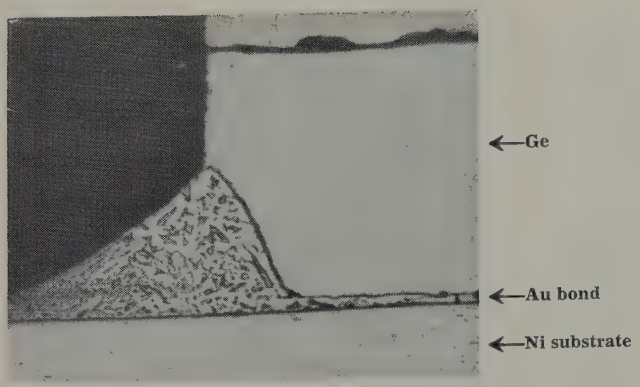

Fig. 1—Ge on Au clad Ni. (From a 250X photomicrograph)

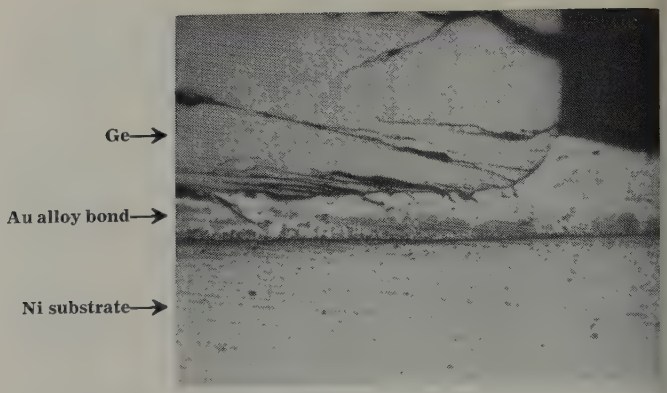

Fig. 2—Ge on Sn plated Au clad Ni, No excess Au. (From a 250X photomicrograph)

Large area contacts were studied using nickel, nickel-iron and molybdenum backing materials which were either gold or gold-alloy clad or plated. In some cases there was an additional tin or antimony plate before alloying. Fabrication temperatures ranged from 300-500°C. All fusions were made under dry hydrogen atmospheres. Vacuum bonding produced similar results, but the technique was not generally used in this study because of the greater ease of alloying under protective gas ambient. In all experimental runs the size of the fusion alloy and geometry of contact were kept constant. The cooling rate was controlled according to the technique described by Peterson and co-workers[6].

Large area electrode attachments where dice were attached to tabs of gold or gold-alloy clad nickel resulted in cracked silicon or germanium unless high ratios of gold to nickel were employed. Results are shown in Fig. 1 (Ge on Au clad Ni). This is typical of silicon as well. Note the horizontal cracking which is typical of thermal expansion mismatch between die and tab.

The iron-nickel alloys are better thermal expansion matches for silicon and germanium, but their thermal and electrical conductivities are poorer. Generally speaking, no cracking problem was observed in making bonds to this type of clad substrate.

Where "scrubbing" action to break through oxide films cannot be employed, and the furnace atmosphere is relatively wet, some other systems must be resorted to. One such example is to plate tin on gold to the proper thickness ratios so that after the tin melts the stoichiometric 80 Au/20 Sn wt % composition is formed. This produces a surface to which Ge and Si can be readily bonded with atmospheric conditions being relatively non-critical. However, if no excess gold remains, the die will crack. Fig. 2 shows this type of attachment to germanium although typical of silicon as well. Note the cracks emanating from the corners as compared with the horizontal cracks described earlier. This type of crack seems more likely to be due to a thermal expansion mismatch between die and solder than between die and substrate. With excess gold on the same backing material, no cracking is observed.

Figure 3 shows a typical attachment using this approach when alloying to silicon (germanium attachment is similar).

This suggests the possible solution to be simply "flashing" the tin on the gold layer before alloy attachment is made.

Gold-boron and gold-arsenic have been successfully used to make p or n-type attachments, respectively, to most resistivity ranges of material. In some cases, primarily those where low resistivity Ge or Si were used or where the total gold and tin thicknesses were greater than .001", it was found necessary to introduce the doping impurity in the Sn layer.

A second method developed for bonding under a non-critical atmosphere for making n^+ attachments

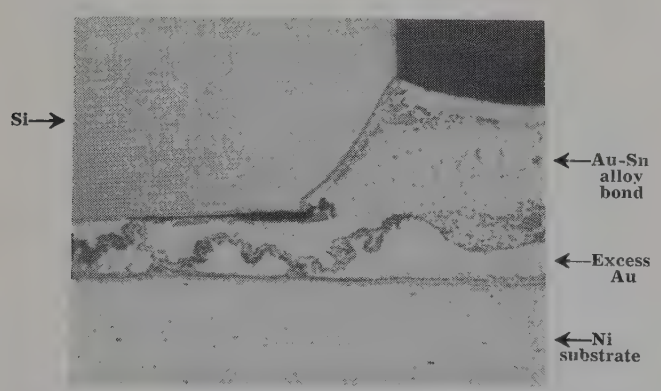

Fig. 3—Si on Sn plated Au clad Ni, excess Au. (From a 250X photomicrograph)

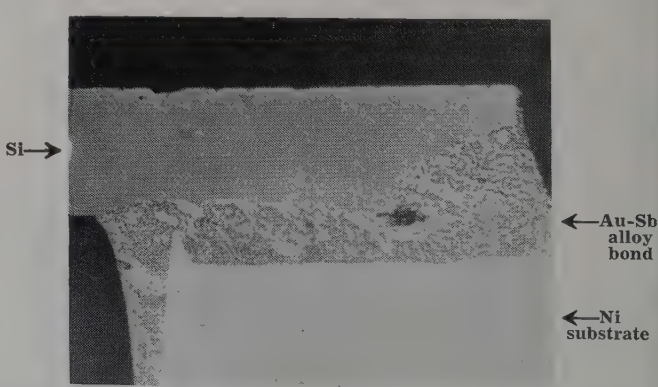

Fig. 4—Si on Sb plate Au clad Ni. (From a 250X photomicrograph)

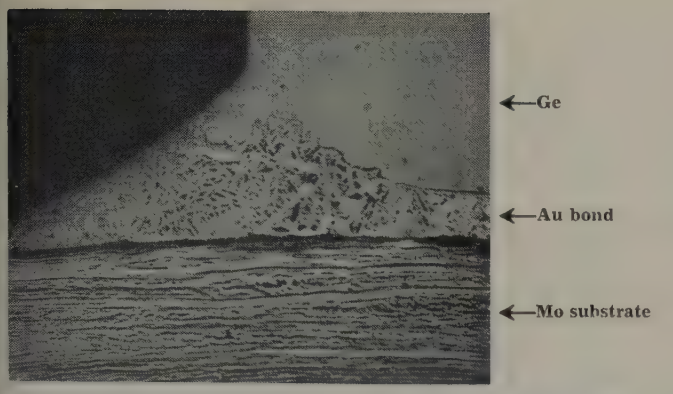

Fig. 5—Ge on Au clad Mo. (From a 250X photomicrograph)

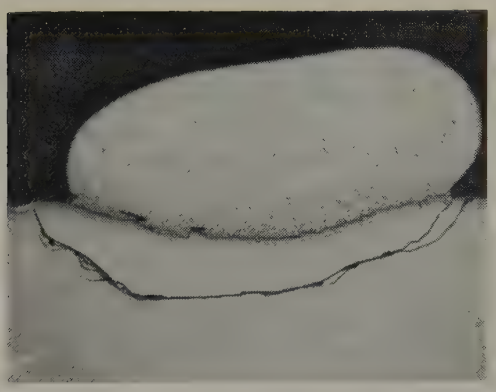

Fig. 6—Au-Sn on Si. (From a 250X photomicrograph)

is to antimony flash the gold clad material. The Sb seems to "flux" the reaction. Fig. 4 demonstrates this effect in the case of Si on Sb plated Au clad Ni, where the ratio of gold to nickel thicknesses (one to ten) is high enough to overcome cracking. The mechanism is probably due to the fact that this is a reaction which results in a ductile layer of excess Au remaining and negates the effect of high Ni expansion.

Where one wishes to achieve a good expansion match with high thermal and electrical conductivity, and magnetic properties are unimportant, molybdenum is the obvious choice for the tab material. Fig. 5 shows an attachment of Ge on gold clad molybdenum. A similar condition exists for silicon and/or gold plated Mo instead of cladding.

It will be shown that indium additions to gold alloys improved wetting properties in making small area contacts, therefore a similar approach was attempted in large area contacts. A 95 Au - 5 In alloy was clad on Fe-Ni and used to make attachments to germanium and silicon dice. General working experience with these materials indicated improved wetting properties.

Small area contacts were studied using eight different gold bearing binary alloys containing Pb, Bi, In, Ga, Ge, Sn, Sb, and Si as the other element.

Generally speaking atmosphere and mechanical forces appear to be the primary factors in determining the kind of bond achieved. With a "poor" atmosphere agitation is required to rupture surface films and permit contact. However, only surface wetting with little or no penetration, without subsequent cracking, occurs. On the other hand, in bonding with an "excellent" atmosphere, only pressure sufficient to hold the parts in good contact is required to initiate wetting which is followed by penetration which sometimes is sufficient to produce cracking upon cooling. In the case where the bond is a thin film either between two large pieces or on top of one of its surfaces, penetration is too shallow to play a role.

Of all the binary alloys studied, Au-Sn was most consistent in its behavior in direct alloying to silicon and germanium under a multitude of conditions. A major limitation of its use is the cracking between the alloy and base semiconductor upon cooling, shown in Fig. 6, after alloying to silicon.

Taylor[1] discusses some remedial measures for making crack-free alloyed junctions. While stress relieving heat treatments were generally used in this study where applicable, the major effort was directed towards alloy modification. Taylor points out six results of alloy modifications which may account for elimination of cracking. A goal of this investigation was to produce an alloy which changed less on freezing or one which was a better thermal expansion match with the semiconductor material. Hence, an evaluation on the basis of thermal expansion data was collected.

Thermal expansion curves of the gold-tin and silicon and germanium are shown in Fig. 7, measured through interferometric techniques on specimens submitted to R. J. Beals, Ceramic Staff, University of Illinois. The curve for gold-tin indicates poor compatibility with germanium and silicon and the non-linearity suggests a possible phase transformation or lattice rearrangement. If this non-linear effect is the cause of the cracking, then it was hypothesized that some means of "flattening out" the expansion curve could overcome this problem. In addition, if the solubility of the Au-Sn phase for silicon and germanium

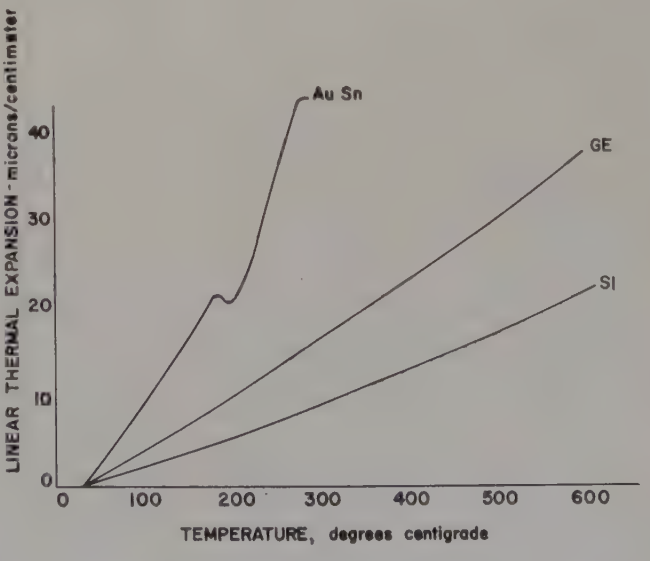

Fig. 7—Thermal expansion curves for Au-Sn, Si and Ge.

were reduced, alloy penetration would be diminished and cracking reduced. Since it is known that small additions to a liquid metal may be considered as impurities, thereby aiding wetting, it was considered that ternary alloys might have the multiple effect noted before. Of course an assumption is made here that if the binary alloy's thermal expansion were more compatible or linear with respect to the semiconductor material, we could extrapolate the data to the ternary system and say that this would probably provide a better thermal match.

Two groups of three ternary alloys were fabricated by adding 2, 3, and 6% silicon and 2, 10, and 15% indium respectively to the Au-Sn eutectic and samples of each were alloyed onto silicon. The addition of silicon diminished but did not entirely eliminate cracking. In all three alloys, penetration was quite limited and no apparent wettability change was noted. Addition of two percent indium appears to improve wetting of the silicon, but the higher indium concentrations impair it. This may be a phenomenon similar to that noted by Bailey,[18] in which successive additions to a liquid metal cause the spreading ability of the solder to go through a maximum. Although none of the additions to the Au-Sn eutectic eliminated the cracking of the silicon surface subsequent to fusion with it, the effect was definitely reduced.

To study the effect of indium additions to the Au-Sn eutectic, thermal expansion curves were run on samples containing 2, 5, and 10% indium (Fig. 8). Increasing the indium content reduced the initial softening temperature in addition to narrowing its range. It is believed that by proper selection of additions, the Au-Sn eutectic alloy can be modified to produce alloy junction and/or small ohmic contacts on silicon and germanium without cracking the surface. Of course whether this doping can be done depends on the segregation of impurities in such a system.

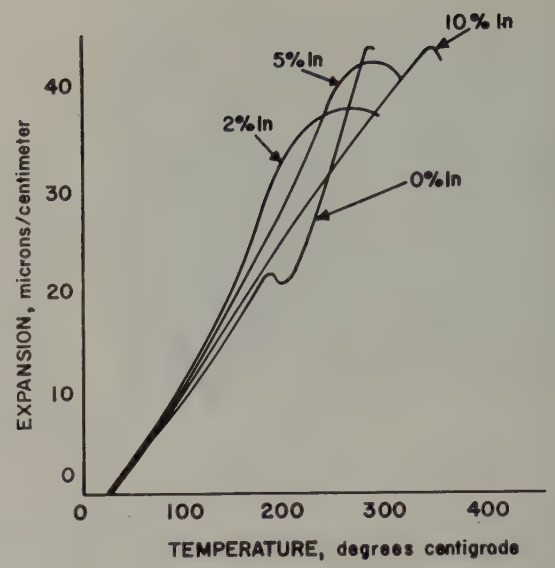

Fig. 8—Linear expansion for Au-Sn alloys.

(To be continued)

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PATENT REVIEW*

Of Semiconductor Devices, Fabrication Techniques and Processes, and Circuits and Applications

Compiled by SIDNEY MARSHALL

The abstracts appearing in this issue cover the inventions relevant to semiconductors from May 5, 1959 to June 2, 1959. In subsequent issues, patents issued from June 2, 1959 to date will be presented in a similar manner. After bringing these abstracts up to date, PATENT REVIEW will appear periodically, the treatment given to each item being more detailed.

May 5, 1959

2,885,483 Telephone Instrument Utilizing Transistor Amplifier—A. H. Faulkner. Assignee: General Telephone Laboratories Inc. A voice current amplifier built within a telephone subset.

2,885,484 Telephone Apparatus Employing Transistor Amplifiers—A. H. Faulkner. Assignee: General Telephone Laboratories Inc. A subscriber controlled telephone subset amplifier and means for mounting it within the set.

2,885,494 Temperature Compensated Transistor Amplifier—S. Darlington, J. H. Felker. Assignee: BTL. A multistage negative feedback amplifier the transmission characteristics of which are controlled by those of the feedback circuit.

2,885,495 Emitter Coupled Transistor Amplifier—G. C. Sziklai, R. D. Lohman. Assignee: RCA. A direct-coupled, broad band, high-input-impedance semiconductor amplifier circuit.

2,885,498 Direct-Coupled Complementary Transistor Amplifier—W. G. Zinn Jr., G. Bruck. Assignee: Avco Mfg. Corp. In an amplifier system an emitter follower transistor circuit is used to control the operating point of a collector load transistor of opposite type.

2,885,544 Automatic Gain Control Using Voltage Drop In Biasing Circuit Common to Plural Transistor Stages—F. E. Radcliffe. Assignee: BTL. Automatic gain control for multistage transistor amplifiers.

2,885,562 Photoelectric Device—J. C. Marinace, U. Cocca. Assignee: General Electric Co. A high energy radiation detecting device.

2,885,568 Generator Control and Protective System—J. R. Reeder, N. F. Schuh, L. R. Lowry. Assignee: Westinghouse Electric Corp. A transistorized a-c generator control and protective system.

2,885,569 Generator Control and Protective System—W. F. Schuh, J. R. Reeder, L. R. Lowry, R. F. Hulsey. Assignee: Westinghouse Electric Co. A control system for use with a multiplicity of parallel connected generators.

2,855,570 Transistor Power Control Circuits—R. L. Bright, G. A. Royer. Assignee: Westinghouse Electric Corp. A control circuit for a transistor used in power control systems in which the minimum load current is a small fraction of the full load current.

2,855,571 Semiconductor Device—R. A. Williams, J. W. Tiley. Assignee: Philco Corp. A device which provides area contact minority carrier injection and which uses area contacts for both emitter and collector.

2,855,572 Transistor Pulse Transmission Circuits—J. H. Felker. Assignee: BTL. A system for transmitting short d-c pulses through a chain of transistor gate circuits with very little time delay.

2,885,573 Transistor Delay Circuit—G. L. Clapper. Assignee: IBM. Signal delay circuit for digital computers provides an output delay by about one bit-time from the input signal.

2,855,574 High Speed Complementing Flip-Flop—A. Roesch Jr. Assignee: Burroughs Corp. A flip-flop circuit operable at speeds up to 10 mc.

2,855,608 Semiconductive Device and Method of Manufacture—W. E. Bradley. Assignee: Philco Corp. Method of manufacture of area contacts to a semiconductive device, said contacts providing efficient minority carrier injection.

2,885,609 Semiconductive Device and Method For The Fabrication Thereof—R. A. Williams, J. W. Tiley. Assignee: Philco Corp. Method of producing an analogue type transistor.

2,885,619 Transistor Driven Magnetic Amplifier—N. Wengryn. Assignee: Kollsman Instrument Corp. A temperature compensating device in which the collector circuit is directly connected to the magnetic amplifier cores.

May 12, 1959

2,885,849 Semiconductor Laping Apparatus—F. Wohlman. Assignee: Hughes Aircraft Co. Packaging apparatus for semiconductor devices whereby said devices are laterally disposed along a length of pressure sensitive tape.

2,886,026 Method and Apparatus For Cutting a Semiconductor Crystal—R. F. Stewart. Assignee: Texas Instruments Inc. In the operation of cutting a grown junction semiconductor crystal, the apparatus and method for maintaining the cutting tool at a fixed distance from the junction of the semiconductor crystal.

2,886,639 Code Converter—R. J. Reek. Assignee: Teletype Corp. A device for adding start and stop impulses to coded signals.

2,886,653 Amplitude Modulated Oscillator Systems—H. C. Lin. Assignee: RCA. An oscillator circuit which can be modulated directly from a high impedance source such as a crystal phonograph pick up.

2,886,706 Blocking Oscillator Pulse Width Control—S. C. Rogers. Assignee: BTL. Means for rendering a blocking oscillator output pulse duration independent of ambient temperature or transistor characteristics.

2,886,739 Electronic Distributor Services—K. A. Matthews. Assignee: International Standard Electric Corp., R. A. Hyman. In an electronic distributor system, pulse counter or trigger, a single or multiple number of semiconductor target electrodes are placed in an electron beam tube to act as detecting elements for impinging electrons.

2,886,740 Deflection Systems—M. B. Finkelstein. Assignee: RCA. A transistor electromagnetic deflection circuit for cathode ray tubes.

2,886,748 Semiconductor Devices—L. E. Barton. Assignee: RCA. A high frequency transistor having low base resistance and closely spaced emitter and collector electrodes.

2,886,754 Push-Pull Motor Drive Circuit—R. J. Ehret. Assignee: Minneapolis-Honeywell Regulator Co. A push-pull transistorized output circuit having transistors connected in a common emitter arrangement and energized from a single power supply.

2,886,755 Servo Motor System Control Apparatus—R. J. Ehret, T. A. Patchell. Assignee: Minneapolis-Honeywell Regulator Co. Control system with means for inducing anti-hunting action in an electric rebalancing motor.

2,886,764 Unidirectional Voltage Multiplier and Divider—W. B. Zelina. Assignee: General Electric Co. A horsepower limit regulator for a d-c generator or motor.

May 19, 1959

2,887,411 Method of Producing Selenium Rectifiers—G. Hoppe, E. Nitsche. Assignee: Siemens Scherckertwerke A. G. In a process involving coating a base plate with multiple impurity containing selenium layers the step of crystallizing said layers by heat treatment prior to

*Source: Official Gazette of the U. S. Patent Office and Specifications and Drawings of Patents Issued by the U. S. Patent Office.

application of the final layer and counter electrode.

2,887,415 Method of Making Alloyed Junction in a Silicon Wafer—A. Stevenson. Assignee: Minneapolis-Honeywell Regulator Co. A method which includes bringing a molten impurity-containing substance into contact with a silicon wafer until alloying of the two takes place.

2,887,416—Method of Alloying an Electrode to a Germanium Semiconductive Body—J. J. van Amstel. Assignee: North American Philips Co. Inc. A fusion technique includes the use of halogen containing fusion agents.

2,887,417 Process for the Manufacture of Alloy-Type Semiconductor Rectifiers and Transistors—H. S. Blanks. Assignee: Marconi Wireless Telegraph Co. Ltd. A sheet of support metal of the desired size and shape is wetted with injector metal and the structure then has a semiconductor wafer fused to the shaped injector metal.

2,887,423 Semiconductor Device—J. R. Beale. Assignee: None. A method of manufacture which results in a device having opposed recrystallized emitter and collector regions of equal size.

2,887,453 Semiconductor Activated with Dissociated Ammonia—E. Billig, D. Bromley. Assignee: Siemens Edison Swan Ltd. A method for introducing nitrogen as an impurity in group IV semiconductors.

2,887,540 Temperature-Compensated Transistor Biasing Circuits—A. I. Aronson. Assignee: RCA. A push-pull amplifier having distortion-free operation over a wide temperature range.

2,887,542 Non-Saturating Junction Transistor Circuits. R. R. Blair, J. R. Harriss. Assignee: BTL. Circuit means for preventing collector current saturation in a common-emitter junction transistor pulse amplifier without reducing gain or causing high current flow therethrough.

2,887,573 Converter with High Frequency Crystal Transistor Oscillator—L. J. Hruska. Assignee: None. A circuit in which signal oscillations occur at a harmonic of the fundamental crystal frequency.

2,887,574 Transistor Oscillator—J. L. Sciurba. Assignee: Motorola Inc. A converter circuit in which transistors of varying gain may be substituted for one another.

2,887,591 Integral Transducer Amplifier System—G. V. Young. Assignee: Video Instruments Co. Inc. An electrical-chopper signal-take off system for a bridge transducer.

2,887,592 Control Circuits for Flasher Lights and the Like—G. M. Stout, E. J. Peterson. Assignee: American Electronics Co. A circuit which provides adjustable timing.

2,887,619 Current Limiting Gating Circuit —L. W. Hussey, W. Peil. Assignee: BTL. A transistorized flip-flop circuit used to control gas tube switching.

2,887,627 Rectifier and Method of Making the Same—J. W. Haas, W. B. England. Assignee: USA (Dept. of the Navy). A hermetically sealed rectifier housing for a selenium device.

2,887,628 Semiconductor Device Construction—C. H. Zierdt. Assignee: General Electric Co. A heat dissipating configuration for a semiconductor device which uses a layer of beryllium oxide to conduct self-generated heat from the device to a metal radiator.

2,887,629 Transistor—L. M. Nijland, J. A. Manintveld. Assignee: North American Philips Co. Inc. A semiconductor body is encapsulated in a sealed envelope containing a halogen or halogen hydrate vapor in order to achieve improved electrical characteristics.

2,887,630 Transistor—L. M. Nijland, J. A. Manintveld. Assignee: North American Philips Co. Inc. A semiconductor body is sealed in a glass envelope containing a nitrogen-oxygen compound vapor.

2,887,631 Electrode System—P. J. Jochems, L. J. Tummers. Assignee: North American Philips Co. Inc. An insulating bridge of material fixes exactly the spacing between free ends of two filamentary electrodes in contact with a semiconductor body.

2,887,632 Zinc Oxide Semiconductors and Methods of Manufacture—H. R. Dalton. Assignee: Timefax Corp. A zinc oxide aluminum semiconductor material is produced by treating zinc oxide with aluminum formate and heating the substance in the presence of hydrogen at a temperature of 800° C.

2,887,633 Titanium Dioxide Rectifier— T. S. Shilliday, A. E. Middleton, C. S. Peet. Assignee: USA (Dept. of Air Force). A device comprising a layer of titanium dioxide semiconductor, a silicon monoxide artificial barrier layer having a thickness of from 1000 to 5000 A and a counter electrode.

2,887,642 Damped Servomotor System— R. J. Ehret, F. Cilyo. Assignee: Minneapolis Honeywell Regulator Co. In a servo motor control system a transistor is employed as a motor driving element and a bridge circuit provides a damping signal.

2,887,658 Frequency Response Determining Apparatus—D. V. Jones. Assignee: General Electric Co. Electrical apparatus for determining the alpha and beta cutoff frequencies for semiconductor devices.

May 26, 1959

2,888,328 Methods of Producing Silicon of High Purity—J. McCreath. Assignee: International Standard Electric Corp. The elimination of boron impurity from silicon by removing all traces of diborane from silane (SiH_4) and then causing thermal decomposition of the silane.

2,888,525 Telescopic Voltage Amplifier— W. S. Eckess, K. I. Sherman, J. E. Davenport. Assignee: Emerson Electric Mfg. Co. An a-c/d-c telescopic voltage amplifier produces an output which exceeds the limitations of the individual transistors.

2,888,578 Transistor Emitter—Follower Circuits—G. D. Bruce, R. A. Henle, J. L. Walsh. Assignee: IBM. The Emitter-follower configurations are employed in logic circuits.

2,888,579 Transistor Multivibrator—C. L. Wanlass. Assignee: North American Aviation Inc. A rapid-response, large current output transistor multivibrator.

2,888,580 Transistor Multivibrator—C. L. Wanlass. Assignee: North American Aviation Inc. A low a-c output impedance device.

2,888,611 Light Controlled Headlight On-Off Switch—E. G. Matkins. Assignee: General Motors Corp. Transistorized system for turning auto headlights "on" or "off" automatically when the ambient light intensity falls below a predetermined level.

2,888,618 Dry Plate Rectifier Assemblies— L. J. Lockett. Assignee: Westinghouse Brake and Signal Co. Ltd. A tubular dry plate rectifier assembly which can be soldered into a circuit without risk of damage to the rectifying element from the heat generated in the process.

2,888,619 Semiconductor Devices—J. P. Hammes. Assignee: USA (Dept of the Army). Methods of potting and mounting point contact transistors.

2,888,620 High Resistance Semiconductor Cells—A. C. Belletdeaux. Assignee: Westinghouse Air Brake Co. In the manufacture of selenium cells, inert granules included in the selenium layer result in cells with high reverse resistance.

2,888,622 Transistor Motor Control—H. T. Mooers. Assignee: Minneapolis-Honeywell Regulator Co. An a-c signal applied to grounded emitter or grounded base circuits described effects control of a d-c device.

2,888,627 Semiconductor Apparatus—A. D. Kompelien, B. H. Pinckaers. Assignee: Minneapolis-Honeywell Regulator Co. A transistor modulator bridge circuit for converting minute d-c signals to a-c signals.

2,888,632 Transistor Current Regulating Circuits—F. M. Livezey. Assignee: The Baldwin Piano Co. A system for supplying a fixed a-c current superposed on a fixed d-c current while the load resistance and d-c source voltage are varying.

2,888,633 Voltage Regulator With Limited Current Drain—R. C. Carter. Assignee: Collins Radio Co. A regulated power supply having an adjustable output voltage, and which permits the determination of a maximum current output limit which cannot be exceeded regardless of overload conditions.

2,888,648 Transistor Reactance Device— F. G. Herring. Assignee: Hazeltine Research, Inc. A low power-consumer reactance device for modulating a megacycle range oscillator.

June 2, 1959

2,888,735 Article Assembling Apparatus— E. D. Hanson. Assignee: Western Electric Co. Apparatus for assembling cartridge type point contact transistors and for obtaining a predetermined contact pressure between the electrode and the semiconductor wafer.

ADDITION

January 13, 1959

2,868,988 Method of Reducing Transient Reference Current—Assignee: Secretary of the Navy. Method of reducing the switching time of semiconductor diodes by irradiating them with high voltage electrons.

SEMICONDUCTOR & SOLID-STATE BIBLIOGRAPHY

TITLE	PUBLICATION	CONDENSED SUMMARY	AUTHORS
A Note on Transistorized Ripple Filters	AWA Tech Rev (Aus) Vol 11 Nov 3 1960	Some basic problems in the design of transistor smoothing circuits for d-c power supplies are discussed and a circuit is described which provides for optimum efficiency over a wide range of load currents without the necessity for critical adjustment.	B. W. Moore J. P. O'Neil
New Methods for Measuring High Frequency Transistor Admittance Parameters using Boonton RX Meter	Amperex Tech News Jan-Feb 1961	This article describes a method of measuring the admittance parameters which overcomes the difficulties of faulty internal oscillator or detector operation.	K. Redmond
The Quantitative Determination of Gallium in Micro Samples by the Graphite Spark	Appd Spectroscopy Vol 15 Nov 1 1961	A solution procedure is employed with spark excitation and moylbdenum as the internal standard. Accuracy of method ranges from 11 to 22%.	E. M. Murt J. C. Beady
Diodes Can Do Almost Anything	Bell Labs Record Jan 1961	Diodes can perform such important electronic functions as: amplification, switching, rectification, generation of high fidelity power, logic, measurement of light intensity, conversion of light to electricity, tuning other networks, triggering, and protection (voltage limiters).	J. H. Forster R. M. Ryder
Margin Considerations for an Esaki Diode-Resistor OR Gate	Bell Syst Tech JL Jan 1961	An Esaki diode-resistor logic, powered from a three-phase supply and involving OR gates is analyzed. Practical switching times are of the order of 10|R-|C.	H. K. Gummel F. M. Smits
Considerations of a Solar Cell	Bell Syst Tech JL Jan 1961	The collection efficiency in solar cells is treated by a new method in which all the effects of the solar spectrum and the absorption curve are contained in a single function readily available by numerical integration.	D. A. Kleinman
Current-Operated Diode Logic Gates.	Comm & Elecncs Jan 1961	Formulation of the general realization procedures applicable to the synthesis of current-operated diode logic networks.	H. Reinecke, Jr.
Thermal Impedance of Semiconductor Devices	Comm & Elecncs Jan 1961	Thermal impedance calculations of cylindrical and spherical sectors are given numerically. The analysis is expanded for long heating cycles by a simple lumped-component approach with limits of validity.	E. J. Diebold W. Luft
Power Semiconductor Ratings Under Transient Loads	Comm & Elecncs Jan 1961	Methods of handling intermittent duty types of applications. Suggested techniques for determining the peak junction temperature under these conditions.	F. W. Gutzwiller T. P. Sylvan
A Transistorized Cable Carrier Repeater	Comm & Elecncs Jan 1961	Description of a repeater designed for a medium-haul cable-carrier system. Emphasis is directed at applications of the repeater as related to the basic problem, and design features and performance of circuitry.	C. G. Griffith
A Transistor AGC System for Audio Frequencies	Comm & Elecncs Jan 1961	System operates in the audio frequency range from 300 to 3,500 cps, which is the pass band for audio frequencies in telephone systems.	J. Shirman
Guide to Semiconductor Voltage Regulators	Control Engineering Jan 1961	A simplified procedure and chart to select the most appropriate solid state voltage regulator to fit the regulated circuit.	L. Bloom
Matching a Given Load To a Transistor Class "B" Stage	Elecl Des News Jan 1961	Discussed are problems where the average collector dissipation rating and where the specified peak collector current rating are given.	S. Bernstein-Bervery
Thermoelectric Cooling of Electronic Components	Elecl Des News Jan 1961	Theory, generalized device considerations, areas of possible application, component coolers, thermoelectric chamber for frequency reference crystals, power supplies and control are discussed.	W. B. Green J. C. Taylor J. R. Fottier, Sr.
Tunnel-Diode Performance in an Oscillator Circuit	Elecnc Design Jan 18 1961	Parameters for tunnel diodes can be calculated and measured by using the device tuned for free sine-wave oscillation.	G. H. Dill
Designing Optimum Transistor Switching Circuits	Elecnc Design Jan 18 1961	A rapid technique using nomograms, for optimizing switching speed with respect to performance and cost.	C. Askanas
A Wide Band Voltage Controlled Oscillator	Elecnc Engg Jan 1961	The various factors affecting oscillator linearity and stability are discussed, and the circuit diagram of an oscillator covering the range 1.5 Mc/s to 3.0 Mc/s is given.	M. A. Weston
Operation and Logic Resistor Transistor Switching Circuits, Part 2	Elecnc Equip Engg Jan 1961	Four basic circuits of this type are analyzed in terms of their modes of operation and their assembly into logic networks.	R. B. Hurley
Electron Tubes and Semiconductors. What's Ahead?	Elecnc Industries Jan 1961	Analysis includes statistical forecast, technical and economic factors.	J. Kraus
Measuring Parameters by Power Transistor Pulse Techniques	Electronics Jan 6 1961	The basic method of testing is to apply biases to the test transistor such that power is drawn in pulses of high peak value. The resulting heating is small.	D. H. Breslow
Ultrasonic Equipment in Industry	Electronics Jan 27 1961	Lists data on characteristics and performance of equipment used in high-power and low-power applications of ultrasonics.	S. Vogel
Ring Counter Uses Transistors	Electronics Jan 27 1961	Current response curves of the bistable circuit resembles the current response of a thyratron. Each stage of the counter uses three transistors, four resistors, two diodes, and contains no capacitors.	J. A. Pecar
Mechanical Measurements Use of Hall Effect	Elecnc Technology Jan 1961	This article deals with the application of the Hall effect to the measurement of non-electrical quantities.	M. Valecz

TITLE	PUBLICATION	CONDENSED SUMMARY	AUTHORS
A Technique for Measuring High-Frequency Transistor Characteristics	Electro-Technology Jan 1961	A complex voltage-ratio meter that measures the absolute value of two voltages or their ratio and the phase angle between them, is described.	R. Fekete
Semiconductor Electronics: 4-Transistor Network Analysis	Electro-Technology Jan 1961	General 4-terminal networks are analyzed in terms of the various possible parameters. The same techniques are then applied to transistor circuits.	A. A. Sorensen
Thermoelectric Refrigeration and its Application	Electro-Technology Jan 1961	Material properties, heat-pumping capacity of a thermoelectric couple, thermoelectric properties of semiconductor materials, and simple system design are discussed.	R. S. Lackey W. L. Wright
The Powerbeam Lamp-A New Fluorescent Light Source	GT & E Res & Dev Jan 1961	A new type of fluorescent lamp is described for applications requiring precise control of light distribution. The lamp has a reflective coating between the phosphor and glass, but is left clear along a long thin aperture.	C. L. Toomey
Reflection and Emission of Polarized Light in ZnS and CdS	GT & E Res & Dev Jan 1961	Results are presented on the reflection of polarized light by single crystals of structurally pure cubic and hexagonal ZnS in the region of the absorption edge.	J. L. Birman H. Samelson A. Lempicki
Theoretical Current Multiplication of a Cylindrical Hook Collector	IBM J1 R & D Jan 1961	An analysis is given of the mechanisms of operation for a current multiplying hook collector of cylindrical geometry. Mathematical equations are presented which establish the minority carrier transport efficiency within a hook collector region.	D. P. Kennedy
Methods of Analysis of Circuit Transient Performance	IBM J1 R & D Jan 1961	Survey of some numerical methods applicable in obtaining the distribution of performance parameters associated with the transient behavior of switching circuits.	L. Hellerman E. J. Skiko
A Stereophonic Transistor Preamplifier	IRE Tr Audio Jan 1961	This preamplifier contains all the controls necessary for stereophonic and monophonic programs, and is designed to drive two transistor power amplifiers.	W. Steiger
Hall Effect Wattmeters	IRE Tr Audio Jan 1961	Analysis of a low frequency structure consisting of a thin wafer of indium antimonide mounted in series with the center leg of a cup core magnetic circuit, and a high frequency structure in which the wafer is placed in the center of a cavity at a position having a maximum in magnetic field and a minimum in electric field for a given cavity excitation value.	D. P. Kanellakos R. P. Schuck A. C. Todd
A Rapidly Responding Narrow-Band Infrared Gaseous CO_2 Analyzer for Physiological Studies	IRE Tr Bio-Med Elecncs Jan 1961	The CO_2 transducer developed employs a Fabry-Perot type interference filter and a lead selenide photoconductive infrared detector.	L. E. Baker
Design Criteria: Transmitter High Voltage Solid State Rectifiers	IRE Tr Bdcasting Jan 1961	Problems encountered and possible solutions in the design of a high voltage power supply using semiconductor rectifiers.	L. R. Zellmer
An Analysis and Representation of Junction Transistors in the Saturation State	IRE Tr Elecnc Devcs Jan 1961	Three diffusion processes are used to analyze the transistor behavior in Region III. This leads to a new equivalent circuit representation which is a superposition of the active-state and saturation-state models.	Z. Wiencek
Determination of Physical Parameters of Diffusion and Drift Transistors	IRE Tr Elecnc Devcs Jan 1961	The dynamic properties of drift and diffusion transistors are studied under both low- and high-level injection conditions in terms of the excess carrier charge in the base region.	M. B. Das A. R. Boothroyd
Theoretical Curves of Drift Transistor Current Drain	IRE Tr Elecnc Devcs Jan 1961	Intrinsic common-base, short-circuit current-gain analysis of drift transistors may be aided by a simplified approximate equation. The accuracy of the equation may be controlled by the investigator.	G. E. Terner
A Coaxially Packaged MADT for Microwave Applications	IRE Tr Elecnc Devcs Jan 1961	A coaxially packaged transistor capable of delivering greater than 11 db of power gain at 1000 Mc, with a resultant maximum frequency of oscillation at 3500 Mc is described.	J. D. Cotter M. J. Walker M. M. Fortini
Solubility of Oxygen in Germanium	JL Appl Phys Jan 1961	The infrared absorbtion band which corresponds to the Ge-O molecular vibration (11.7 μ) is quantitatively correlated to the oxygen content of germanium crystals.	W. Kaiser C. D. Thurmond
Germanium Saturated With Gallium Antimonide	JL Appl Phys Jan 1961	The solubility of antimony is increased in the presence of gallium but the converse is not true.	J. O. McCalding D. B. Wittry
Uniformity of Electrical Current Flow In Cylindrical Semiconductor Specimens with Cylindrical Metal End Caps	JL Appl Phys Jan 1961	If specimen resistivities are greater than 200 times that of the end caps and if specimen diameters are greater than their lengths, less than 1% nonuniformity of longitudinal current density can be obtained.	R. Simon J. H. Cain J. C. Bell
Catalytic Activity of p- and n-Type Germanium	JL Appl Phys Jan 1961	Experiments are performed which use In and Sb doped germanium as catalysts for reactions generally catalyzed by electron acceptors. (Letter to the Editor)	W. H. Watson, Jr.
Electron Mobilities and Tunneling Currents in Silicon	JL Appl Phys Jan 1961	The dependence of diode current upon carrier density is examined. (Brief Note)	R. A. Logan J. F. Gilbert F. A. Trumbore
Thermal Expansion and Related Bonding Problems of Some III-V Compound Semiconductors	JL Appl Phys Jan 1961	Experiments indicate that expansion departs from a linear function between 300° and 400°C. (Letter to the Editor)	L. Bernstein R. J. Beals
Variation of LF Noise Figure of a Junction Transistor	Jl British IRE Jan 1961	The flicker noise components is of great interest in the operation of transistors. Theory and methods of measurements for determining how it varies with input current and temperature.	S. Deb A. N. Daw
Symmetrical Transistors	Jl British IRE Jan 1961	The differences in performance between a symmetrical and an unsymmetrical alloy junction transistor are analyzed: telecommunication circuits are given in which the use of symmetrical transistors offer significant improvements.	G. H. Parks
Growth From the Vapor of Large Single Crystals of Lead Selenide of Controlled Composition	JL Electrochem Soc Jan 1961	Lead selenide crystals have been grown by sublimation using a technique in which almost the whole charge of a few grams is frequently converted into only one single crystal. Carrier concentrations more than an order lower than has been achieved in crystals grown from the melt have been obtained.	A. C. Prior

TITLE	PUBLICATION	CONDENSED SUMMARY	AUTHORS
Electrolytic Polish for Lead Telluride	JL Electrochem Soc Jan 1961	The purpose of this note is to describe a modification of a chromic-phosphoric electropolish which produces an excellent polish-etch on all crystallographic planes in lead telluride.	P. H. Schmidt
Resistivity Striations in Germanium Single Crystals	Jl Phys Soc Jap Jan 1961	Resistivity striations resulting from periodic distribution of impurities have been observed in single crystals of germanium grown horizontally.	H. Ueda
Thermoelectrically Cooled Probe for the Determination of Semiconductor Type	Jl Scient Instments (Br) Jan 1961	A convenient method for determination of semiconductor type is to determine the sign of the thermally generated e.m.f. arising when a probe of different temperature is placed in contact with the sample.	R. V. Jeanes K. E. G. Pitt
Circuit Parameter Calculations for a Stepped-Voltage Reference Generator	Meas Techniques Izmer Tekh (tr) Jan 1961	The aim of this article is to analyze the operation of a reference stepped voltage generator operating in a "diode pump" circuit, and to establish a criterion for selecting parameters of its basic elements.	M. A. Zemel'man
Compensation for Diode Nonlinearity	Meas Techniques Izmer Tekh (tr) Jan 1961	The compensation method suggested in this article consists of using a potential divider which is made up of nonlinear resistances, and which provides a linear relation of the rectified voltage (current) to the a-c voltage.	A. E. Vishnyakov
Survey of Electronically Scanned Antennas	Microwave Jl Jan 1961	Includes semiconductor phase shifter.	H. Shnitkin
Fundamental Consideration of Microwave Video Diodes	Microwave Jl Jan 1961	Survey article on the crystal-video diode which is now used quite extensively as a low level detector in the microwave frequency range.	R. L. Thomas
A Companion of the Reliability of Relay and Transistorized Logic Circuits	NARM Symp Papers 8th Annual Relay Symp	One area where transistors have found wide applications and in many instances have displaced relays is in the logic functions of computers and similar equipments.	W. O. Hansen J. Popa
Ancient Relays to Modern Logic	NARM Symp Papers 8th Annual Relay Symp	Relay manufacturers and relay users are told how they can better make use of each other by considering the "switching problem" rather than a specific relay design. A number of attempts are made to combine relays with solid state sensing devices.	P. T. Millunzi
Recombination Radiation From Silicon Under Strong Field Conditions	Physical Review Jan 15 1961	Measurements have been made of the spectral distribution of recombination radiation at 77°K (field strengths up to 3700 cm^{-1}) and at 20°K.	L. W. Davies A. R. Storm Jr.
Effect of Photoexcitation on the Mobility in Photoconducting Insulators	Physical Review Jan 15 1961	The Hall mobility of carriers in photoconducting insulators can be varied over an appreciable range by the effects of photo-excitation.	R. H. Bube H. E. McDonald
Computer Memories: A Survey of the State of the Art	Proc IRE Jan 1961	Computor memory developments in the last decade, the present state, and efforts for improvements are surveyed.	J. A. Rajchman
A Computer Subsystem Using Kilomegacycle Subharmonic Oscillators	Proc IRE Jan 1961	An investigation was made of the problems associated with a high speed carrier computer, and a computer subsystem was constructed employing subharmonic oscillators driven with a 3.7 Mc sine wave source.	A. F. Borgini
A Survey of Tunnel-Diode Digital Techniques	Proc IRE Jan 1961	Efforts have been devoted to its application in both memory and logic circuits. Results have been most promising in high speed random access memories and in dynamic logic systems utilizing multiphase clock sources.	R. C. Sims E. R. Beck Jr. V. C. Kamm
Calculated Waveforms for Tunnel Diode Locked Pair	Proc IRE Jan 1961	An introductory analysis of the tunnel diode locked-pair circuit is presented. The characteristics of the tunnel diode together with the simplicity of the locked-pair make it a major contender for use as a high speed computer element.	H. R. Kaupp D. R. Crosby
Magnetic Film Memory Design	Proc IRE Jan 1961	A simple rotational model modified to include the effects of wall switching and dispersion of the preferred direction of magnetization provides a basis for describing properties of engineering interest.	T. S. Crowther A. H. Anderson J. I. Raffel T. O. Herndon
Computer Generated Displays	Proc IRE Jan 1961	This paper explains techniques for performing key display functions; in particular, 1) digital-to-image conversion with symbol generation, and 2) generation of large, bright displays.	R. T. Loewe R. L. Sisson P. Horowitz
Statistical Analysis of Logic Circuit Performance in Digital Systems	Proc IRE Jan 1961	Both algebraic and numerical (Monte Carlo) methods are considered. Transistor resistor logic circuits are then analyzed in more detail.	E. Nussbaum E. A. Irland G. E. Young
Tests and Comparison of Carbon and Germanium Thermometers	Rev Scient Instmnts Jan 1961	Two encapsulated germanium thermometers have been calibrated and tested between 1.4° and 4.2°. In some respects germanium thermometers were found to be considerably better than carbon thermometers.	P. Lindenfeld
A 100-db Microwave Semiconductor Switch	Rev Scient Instmnts Jan 1961	A dual-diode microwave switch providing in excess of 100-db switched attenuation with low insertion loss is described. Switching time is 3×10^{-7} sec.	D. W. Feldman B. R. McAvoy
Sensitive Output Indicator for Differential Transformer Displacement Determinations	Rev Scient Instmnts Jan 1961	A transistorized circuit is used. The advantages of a phase-sensitive detector for the measurements of small displacements is discussed. Resolution is about 0.5 μ; linearity about ¼%.	D. Wobschall
Low-Level Linear Microsecond Gate	Rev Scient Instmnts Jan 1961	A linear transmission gate for use with scintillation counter coincidence experiments is described. The gate is suitable for negative pulses of microsecond duration and is linear over a range of 0.01 to 5 volts.	P. R. Chagnon
Diode Parametric Amplifiers Principles and Experiments, Part I	Semiconductor Prods Jan 1961	The physical principles involved in the operation of the major types of diode parametric amplifiers are reviewed and a qualitative explanation given of the variable capacitance effect in semiconductor diodes.	E. D. Reed
A Survey of Semiconductor Devices and Circuits in Computers. Part III	Semiconductor Prods Jan 1961	The following topics are discussed: basic logic circuitry, direct-coupled transistor logic circuitry, regenerative switches, and current switching.	V. A. Marsocci
Microphotographs For Electronics	Semiconductor Prods Jan 1961	Description and application of two cameras designed to prepare microphotographs for the fabrication of semiconductor devices, and micro-electronic solid circuits, by photoengraving and photomechanical techniques.	T. C. Hellmers, Jr. J. R. Nall

TITLE	PUBLICATION	CONDENSED SUMMARY	AUTHORS
Spectral Response of Solar Cell Structures	Solid State Elecncs (Br) Jan 1961	Measurements were made of the spectral response of silicon solar-cell structures, and observations were made on how the response varied with the depth of the p-n junction.	L. M. Terman
Impurity Concentrations in the Regrown Region of In-Ge Alloyed Junctions	Solid State Elecncs (Br) Jan 1961	A study is made of regions of a size normally used in transistors with an infrared microscope; the development of the latter being described.	F. E. Roberts
A Rapid and Accurate Method for Measuring the Thickness of Diffused Layers in Silicon and Germanium	Solid State Elecncs (Br) Jan 1961	Surface-layer thicknessses can be measured very practically by making use of the brittleness of silicon and germanium.	B. Jansen
Recent Advances in Micro-Miniaturization, Reliable Components and Cooling Techniques	Solid State Elecncs (Br) Jan 12961	A summary of the recent work done in these fields at Royal Radar Establishment.	G. W. A. Dummer
Problems Related to p-n Junctions In Silicon	Solid State Elecncs (Br) Jan 1961	The phenomena of secondary ionization, avalanche breakdown, and microplasma phenomena in p-n junctions are analyzed using a simplified model in which holes and electrons have identical properties described by four constants.	W. Shockley
Study of the Oriented Growth of Germanium on a Single Crystal of Fluorite	Tech Transl Jan 13 1961 Acad Sciences (Fr)	Order from SLA. $1.80. No. 60-14489. SLA Translation Center. The John Crevar Lib., 86 E. Randolph St., Chicago, Ill.	
Influence of an Electric Field on Current Carrier Mobility in Semiconductors	Tech Transl Jan 13 1961 Izves VUZ Fig (USSR)	Order from MDF. Morris D. Friedman Inc., P.O. Box 35, West Newton 65, Mass. $3.00. No. MDF 1-125.	
Adsorption of Molecules and Photoconduction of Cuprous Oxide	Tech Transl Jan 31 1961 Akad Nauk SSSR	Order from SLA, $1.80. No. 61-10130. The change of photoconductivity with vapor pressures of the adsorbed substances indicates that the phenomenon is due to the surface of the semiconductor.	V. I. Lyashenko
Double Diffused Germanium NPN Transistors	Tech Transl Jan 13 1961 L'Onde Elec (Fr)	Order from SLA. $6.30. No. 60-18901. An original method of producing germanium transistors by two successive diffusions.	R. Deschamps
The Preparation of Polymeric Materials with Semiconductor Properties	Tech Transl Jan 13 1961 Int Symp M Chem (USSR)	Order from SLA. $1.80. No. 61-10018. Thermal treatment of polymeric materials yielded substances giving signals in the ER spectrum and possessing semiconductor properties.	M. A. Geyderikh B. Ye Davydov
Semiconducting Materials	US Govt Res Repts Jan 13 1961 LC $10.80 PB150537	The mechanism of recombination is studied.	T. J. Gray
Phosphorus Diffusion Into Silicon Through an Oxide Layer	US Govt Res Repts Jan 13 1961 LC $10.80 PB152185	A discussion of empirical results and of theoretical considerations is given on the oxidation of silicon and the solid state diffusion of phosphorus into silicon under oxidizing conditions.	D. Kahng M. O. Thurston
Study of Surfaces in Semiconductor Devices	US Govt Res Repts Jan 13 1961 LC $4.80 PB150811	The results of a 1000 hour continuing reliability study of diffused junction diodes protected by a thick bonded polysiloxane layer.	T. C. Hall
Study of Surfaces In Semiconductor Devices	US Govt Res Repts Jan 13 1961 LC $3.30 PB150812	A study of the effects of thickened oxide films on the properties of silicon p-n bar diodes.	T. C. Hall
Study of Semiconductor Devices By Analogue Techniques	US Govt Res Repts Jan 13 1961 LC $15.30 PB150525	Physical phenomena in semiconductor devices are described in terms of lumped models and an analogue computer is set up to simulate the equations derived from these models.	R. Bharat
On the Kinetics and Mechanism of Precipitation of Lithium from Germanium	US Govt Res Repts Jan 13 1961 LC $6.30 PB150501	Precipitation rates, thermal history, and the influence of impurity additions on the kinetics of lithium precipitation are discussed.	J. R. Carter Jr. R. A. Swalin
Some Semiconducting Properties of Bismuth Trisulphide and Bismuth Trioxide	US Govt Res Repts Jan 13 1961 LC $7.80 PB150784	Technical note on electrical, optical and thermal properties of the semiconductors.	D. M. Mattox
Solid State Research	Jan 13 1961 US Govt Res Repts LC $15.30 PB150603	A progress report containing information on semiconductor device design, chemistry, materials research, components, etc.	No Author
Short Carrier Lifetimes and the Photo-magnetoelectric Effect	US Govt Res Repts Jan 13 1961 LC $7.80 PB150686	The photo-magnetoelectric effect is employed to study carrier lifetime in germanium. Both theory and empirical results are presented.	F. A. Brand
Semiconductor Delay Lines	US Govt Res Repts Jan 13 1961 LC $1.80 PB150609	Equations are developed for the delay and rise times which are associated with the drift of minority carriers in an electric field in semiconductors.	J. J. McClue
Packaging and Integration of Transistor Assemblies	US Govt Res Repts Jan 13 1961 LC $27.30 PB150810	A report on packaging of transistor printed circuit assemblies.	R. Albon D. N. Lightbourne R. L. Meek
Packaging and Integration of Transistor Assemblies. Design Guide	US Govt Res Repts Jan 13 1961 LC $16.80 PB150809	A guide for the design engineer which provides information for packaging printed circuit subassemblies.	R. Albon D. N. Lightbourne R. L. Meek
Crystal Rectifiers	Jan 13 1961 US Govt Res Repts LC $4.80 PB152657	A discussion of the applications and fabrication of gold bonded diodes suitable for use in microwave systems.	No Author
High Temperature Semiconductor Research	US Govt Res Repts Jan 13 1961 LC $10.80 PB150963	A compilation of discourses on material preparation, impurity behavior, material properties, and device studies.	J. Blanc R. Bube Et al
Research in Electron Emission From Semiconductors	US Govt Res Repts Jan 13 1961 LC $4.80 PB150816	The voltage dependence of hot electron emission is compared to that of field induced photoemission to determine avalanche breakdown voltages in Si and Ge.	A. H. Sommer W. E. Spicer
Logic Symbols for Data Processing Equipment	West Elec Engr Jan 1961	Newly developed logic symbols are being used to explain the functioning of data processing equipment in much the same way that electrical schematics have been used to explain the operation of electrical circuits.	M. P. Duncan

Market News . . .

Sales

Western Electric Co. has established a sales office in Los Angeles and in Chicago to handle their semiconductor line as part of a program to broaden their position in the military equipment market.

Dixon Electronics Corp., Scottsdale, Ariz., has named Microwave International Corp., New York as their export representative for their lines of Zener diodes, reference diodes and high voltage rectifiers.

The Japanese semiconductor industry expects to gradually increase their production of silicon transistors during the next few years. Last year, Japanese production of these units was estimated at one-tenth of 1% of all transistor output. This low percentage was mostly caused by the average price of silicon crystals of 55¢ per gram against the 15¢ per gram for germanium. As improvements in the output characteristics of silicon transistors are obtained and Japanese production of silicon crystals is increased, more silicon transistors will be produced. It is expected to be some time before these units will be exported in quantity.

According to a United States trade commission touring West Germany for the Department for International Affairs, Department of Commerce, Berlin could be a major market for such components as tunnel diodes, transistors and materials associated with electronics.

The Lansdale Division of Philco Corp., Semiconductor Operations, plans to market epitaxial transistors this summer.

The Division has also established a nationwide organization of franchised manufacturers' agents to represent its Equipment Manufacturing Operations. This division is devoted solely to the design and fabrication of such equipment as crystal growing furnaces, zone refiners, wafer etchers, scribers, and encapsulation mechanisms.

According to the Marketing Data Department of the Electronic Industries Associations factory sales of transistors showed a healthy gain in March of 1,858,845 units worth $4,115,666 over February totals.

	Factory Sales(Units)	Factory Sales (Dollars)
March	15,129,273	$29,815,291
February	13,270,428	25,699,625
January	12,183,931	22,955,167
Jan.-Mar. '61	40,583,632	78,470,083
Jan.-Mar. '60	31,155,798	78,246,279

Prices

Increased demand for 99.7% pure commercial grade tellurium has resulted in an increase of $1.25 a pound. The metal is now $5.25 a pound. Prices of high-grade quality have remained unchanged at $12-15 per pound for the 99.99% purity and at $22.50-30 for the 99.999% grade.

Sylvania has announced that its 2N705 epitaxial germanium mesa transistor has been granted military approval by the U. S. Navy. MIL-S-19500/86 units are available from stock and from franchised distributors at the following prices: 1-99: $16.50, 100-999: $11.00, 1000 and up: $9.90. They have a total rise and fall time of less than 175 nanoseconds and absolute maximum voltage ratings of 15 volts, according to the company.

Raytheon's Semiconductor Division has reduced prices on 18 silicon subminiature transistors. In quantities of 100 to 999, new prices range from 6 to 41% below former prices. Included are seven double-ended types 2N902 to 908 now are $9.55 to $15 each. The single-ended units 2N745, 746 and 789 through 793 are between $8.70 and $13.65. The 2N747 to 751 are now offered from $7.50 to $27 each.

Suppliers

Semi-Elements, Inc., Saxonburg, Pa., is now in pilot production on lead telluride. It is available both as a single crystal and in polycrystalline form, in both n and p type materials. Price is 50¢ per gram in kilogram lots or less.

The Lansdale Division of the Philco Corporation will further expand the Division's Transistor operations and gradually discontinue the manufacture of receiving tubes throughout the remainder of 1961. This action has been forced by economic factors arising out of the increased use of transistors in electronic equipment, and the shrinking tube market.

Allegheny Electronic Chemicals Co., Bradford, Pa., has begun quantity production of highly polished single crystal silicon wafers. Representative prices for a low resistivity n-type slice is approximately $2.49 each.

Solitron Devices, Inc., Norwood, N.J., has announced prices on their double diffused, axial type silicon rectifier with a hermetically sealed insulated body. Depending upon the voltage, current and quantity these are priced from 40¢ to $8 each.

Hoffman Electronics Corp., Semiconductor division has made commercially available a negative-positive silicon solar cell. These n-p units have an electrical conversion efficiency of 10% or greater. Type N120CG-10 is priced at $15 each.

Texas Instruments has introduced two medium power silicon mesa p-n-p transistors to operate in linear and non-linear circuits. Available in a TP-5 package they are priced: 2N1131 at $19.25 each in lots up to 99 units, and $14.40 each in lots of 100-999; 2N1132 at $20.90 and $15.65 in the same lots respectively.

Distributors

Sun Radio and Electronics Co., New York has been named a distributor for Silicon Transistor Corp., Carle Place, L.I., N.Y.

North American Electronics, Inc. has announced the establishment of an Authorized Industrial Distributor program for their three product lines, Silicon Rectifiers, Controlled Rectifiers, and Voltage Regulators. The major areas served are: New England—North East Electronic Distributors; Buffalo, New York—Summit Distributors; New York City—Electronic Center; Long Island—Hempstead Electronics; New Jersey—Atlas Electronics; Philadelphia—Almo Radio; Ohio—Akron Electronics; Los Angeles—Graybar Electric Company.

The Birtcher Corporation's Industrial Division has announced the appointment of the Busacker Electronic Equipment Co., Inc. of Houston, Texas as distributor for its line of tube, transistor and component retention and cooling devices for the state of Texas.

Financial

General Instrument Corp., has earned a net profit of $3,424,891 for the fiscal year ending Feb. 28, 1961 which is 29% above the $2,655,652 in the year-ago period. Earnings were equal to $1.41 per share against $1.23 a share the year prior. Sales rose 6% to $70,644,123 for $66,895,542. The company claims its semiconductor sales gains outpaced the increases of the semiconductor industry as a whole.

Sprague Electric Company, North Adams, Massachusetts, has declared a quarterly dividend of 30 cents per share on the Company's common stock, payable on June 14 to the stockholders of record at the close of business on May 29, 1961.

Cetron Electronic Corporation in its first annual report to shareholders has reported registered sales of $791,083 and net income of $55,553, equal to 7½ cents per share on the 734,245 shares outstanding, for the fiscal year ended November 30, 1960.

(Continued on page 43)

CHARACTERISTICS CHART of NEW TRANSISTORS

MANUFACTURERS (In Order of Code Letters)

ARA— Advanced Research Associates, Inc.
AEG— Allgemeine Elecktricitats-gesellschaft
AMP— Amperex Electronic Corp.
AEIE— Associated Electrical Industries Ediswan Div.
AEIL— Associated Electrical Industries Export
ATLB— Associated Transistors Ltd.
BEN— Bendix Corp.
CBS— CBS Electronics
CDLF— Compagnie des Lampes
CSF— Compagnie Generale
CRY— Crystalonics, Inc.
CTP— Clevite Transistor Products, Inc.
DEL— Delco Radio Div., General Motors Corp.
ELE— Electromation Co.
ETC— Electronic Transistor Corp.
FSC— Fairchild Semiconductor Corp.
FTHF— French Thompson-Houston Semiconductor Dept.
FCAJ— Fuji Communication Apparatus Manufacturing Co.
GECB— General Electric Co., Ltd.
GE— General Electric Co.
GIC— General Instrument Corp.
GEM— Great Eastern Mfg. Co.
HITJ— Hitachi Ltd., Mushashi Works
HIVB— Hivac Ltd.
HSD— Hoffman Semiconductor Div.
HUG— Hughes Aircraft Co.
IND— Industro Transistor Corp.
INTG— Intermetall
KSC— Kearfott Semiconductor Corp.
KOKJ— Kobe Kogyo Corp.
LCTF— Labortoire Central de Telecommunications
MIN— Minneapolis-Honeywell Regulator Co.
MISI— Mistral
MOT— Motorola, Inc.
MUL— Mullard Ltd.
NAC— National Semiconductor Corp.
NTLB— Newmarket Transistors Ltd.
NECJ Nippon Electric Co. Ltd.
PSI— Pacific Semiconductors. Inc.
PHI— Philco Corp., Lansdale Division, Semiconductor Operations
RAY— Raytheon Co.
RCA— Radio Corp. of America, Semiconductor Div.
RDR— Radio Development and Research
RADF— La Radiotechnique, Div. Tubes Electroniques
RHE— Rheem Semiconductor Corp.
ROSG— Dr. ing. Rudolph Rost
SANJ— Sanyo Electric Co. Ltd.
SIE— Siemens & Halske Aktiengesellschaft
SIL— Silicon Transistor Corp.
SGSI— Societa General Semiconduttori
SONY— Sony Corp.
SPE— Sperry Rand Corporation
SPR— Sprague Electric Co.
STCB— Standard Telephone & Cables, Ltd.
STCA— Standard Telephones and Cables Pty, Ltd.
TKAD— Suddeutsche Telefon-Apparate-, Kabel und Drahtwerke
SYL— Sylvania Electric Products Inc.
TOSJ— Tokyo Shibaura Electric Co.
TRA— Transitron Electronic Corp.
TFKG— Telefunken Ltd.
TI— Texas Instruments Incorporated
TIIB— Texas Instruments Ltd.
TUN— Tung-Sol Electric, Inc.
UST— U. S. Transistor Corp.
WEC— Western Electric Co., Inc.
WTC— Western Transistor Corp.
WEST— Westinghouse Electric Corp.

TYPE NO.	USE (See Code Below)	TYPE (See Code Below)	MAT	Max. Ratings @ 25° C.				Typical Characteristics			MFR. See Code
				P_C (mw)	DERATING °C/W	V_{CB}	V_{CE}	$f_{\alpha b}$ (mc)	GAIN PARAMETER And (Condition)	GAIN VALUE	
2N779A	5	PNPMAD	Ge	60	1250	15	15	450#	h_{FE}:I_C- 10ma	90	PHI
2N799	5	PNPA	Ge	75	800	25	24	12	h_{FE}:I_B-.40ma	30min	RAY
2N800	5	PNPA	Ge	75	800	25	24	12	h_{FE}:I_B-.40ma	30min	RAY
2N801	5	PNPA	Ge	75	800	30	18	6.0	h_{FE}:I_B-1.0ma	30-60	RAY
2N802	5	PNPA	Ge	75	800	30	18	6.0	h_{FE}:I_B-1.0ma	30-60	RAY
2N803	5	PNPA	Ge	75	800	30	15	11	h_{FE}:I_B-1.0ma	40-80	RAY
2N804	5	PNPA	Ge	75	800	30	15	11	h_{FE}:I_B-1.0ma	40-80	RAY
2N805	5	PNPA	Ge	75	800	30	12	17	h_{FE}:I_B-1.0ma	60min	RAY
2N806	5	PNPA	Ge	75	800	30	12	17	h_{FE}:I_B-1.0ma	60min	RAY
2N807	5	PNPA	Ge	75	800	25	12	18	h_{FE}:I_C- 20ma	40min	RAY
2N808	5	PNPA	Ge	75	800	25	12	18	h_{FE}:I_C- 20ma	40min	RAY
2N809	4	PNPA	Ge	75	800	30	15	7.0	h_{fe}:V_{ce}-6.0V	60	RAY
2N810	4	PNPA	Ge	75	800	30	15	7.0	h_{fe}:V_{ce}-6.0V	60	RAY
2N811	4	PNPA	Ge	75	800	30	12	10	h_{fe}:V_{ce}-6.0V	80	RAY
2N812	4	PNPA	Ge	75	800	30	12	10	h_{fe}:V_{ce}-6.0V	80	RAY
2N813	4	PNPA	Ge	75	800	30	10	20	h_{fe}:V_{ce}-6.0V	160	RAY
2N814	4	PNPA	Ge	75	800	30	10	20	h_{fe}:V_{ce}-6.0V	160	RAY
2N815	5	NPNA	Ge	75	800	25	20	8.0	h_{FE}:I_C-200ma	30min	RAY
2N816	5	NPNA	Ge	75	800	25	20	8.0	h_{FE}:I_C-200ma	30min	RAY
2N817	5	NPNA	Ge	75	800	30	25	2.5Ø	h_{FE}:I_C- 50ma	20min	RAY
2N818	5	NPNA	Ge	75	800	30	25	2.5Ø	h_{FE}:I_C- 50ma	20min	RAY
2N819	5	NPNA	Ge	75	800	30	20	5.0Ø	h_{FE}:I_C- 50ma	30min	RAY
2N820	5	NPNA	Ge	75	800	30	20	5.0Ø	h_{FE}:I_C- 50ma	30min	RAY
2N821	5	NPNA	Ge	75	800	30	15	10Ø	h_{FE}:I_C- 50ma	50min	RAY
2N822	5	NPNA	Ge	75	800	30	15	10Ø	h_{FE}:I_C- 50ma	50min	RAY

TYPE NO.	USE (See Code Below)	TYPE (See Code Below)	MAT	Max. Ratings @ 25° C.				Typical Characteristics			MFR. See Code
				P_C (mw)	DERATING °C/W	V_{CB}	V_{CE}	$f_{\alpha b}$ (mc)	GAIN PARAMETER And (Condition)	GAIN VALUE	
2N2021	3	NPND	Si	40W	.266	200	200	10#	h_{FE}:I_C-100ma	25min	TRA
2N2033	2	NPN	Si	40		80		2.0	h_{FE}:I_E-200ma	25	SIL
2N2034	2	NPN	Si	40		120		2.0	h_{FE}:I_E-200ma	25	SIL
2N2035	2	NPN	Si	40		80		2.0	h_{FE}:I_E-200ma	50	SIL
2N2036	2	NPN	Si	40		120		2.0	h_{FE}:I_E-200ma	50	SIL
2N2049	3	NPNPL	Si	800		75		50†Ø	h_{FE}:I_C-.10ma	60min	FSC
2SA32	2	PNPA	Ge	100		20		10	h_{fe}:I_e-1.0ma	65	FCAJ
2SA33	2	PNPA	Ge	100		20		6.0	h_{fe}:I_e-1.0ma	65	FCAJ
2SA138	2	PNPA	Ge	80		20		15	h_{FE}:I_C- 10ma	70	FCAJ
2SA188	2	PNPA	Ge	80		12		10	h_{fe}:I_e-1.0ma	65	FCAJ
2SA189	2	PNPA	Ge	80		12		6.0	h_{fe}:I_e-1.0ma	65	FCAJ
2SA251	2	PNPM	Ge	50		15		50	h_{fe}:I_e-1.0ma	50	FCAJ
2SA252	2	PNPM	Ge	50		15		80	h_{fe}:I_e-1.0ma	150	FCAJ
2SA253	2	PNPMe	Ge	200		20		450	h_{fe}:I_e- 10ma	30	FCAJ
2SB16A	3	PNPA	Ge		25Ø	20			h_{fe}:I_C- 50ma	50	FCAJ
2SB17A	3	PNPA	Ge		25Ø	40			h_{FE}:I_C- 50ma	50	FCAJ
2SB18A	3	PNPA	Ge		25Ø	80			h_{FE}:I_C- 50ma	50	FCAJ
2SB19	2	PNPA	Ge		8.2Ø	16			h_{FE}:I_C- 50ma	50	FCAJ
2SB20	2	PNPA	Ge		8.2Ø	32			h_{FE}:I_C- 50ma	50	FCAJ
2SB21	2	PNPA	Ge		8.2Ø	60			h_{FE}:I_C- 50ma	50	FCAJ
2SB57	2	PNPA	Ge	100		30		1.0	h_{fe}:I_e-1.0ma	65	FCAJ
2SB59	2	PNPA	Ge	100		30		1.0	h_{FE}:I_C- 50ma	70	FCAJ
2SB60	2	PNPA	Ge	100		20		1.0	h_{fe}:I_e-1.0ma	65	FCAJ
2SB60A	2	PNPA	Ge	100		20		1.0	h_{FE}:I_C- 50ma	70	FCAJ
2SC26	3	NPNMe	Si	500		60		150	h_{fe}:I_e- 10ma	50	FCAJ

TYPE NO.	USE (See Code Below)	TYPE (See Code Below)	MAT	Max. Ratings @ 25° C. P_C (mw)	DERATING °C/W	V_{CB}	V_{CE}	Typical Characteristics $f_{\alpha b}$ (mc)	GAIN PARAMETER And (Condition)	GAIN VALUE	MFR. See Code
2N823	5	NPNA	Ge	75	800	25	24	12	h_{FE}:I_C- 20ma	40min	RAY
2N824	5	NPNA	Ge	75	800	25	24	12	h_{FE}:I_C- 20ma	40min	RAY
2N825	5	PNPA	Ge	75	800	30	20	8.0	h_{FE}:I_C- 10ma	30-150	RAY
2N826	5	PNPA	Ge	75	800	30	20	8.0	h_{FE}:I_C- 10ma	30-150	RAY
2N846A	5	PNPMAD	Ge	60	1250	15	15	450#	h_{FE}:I_C- 10ma	50	PHI
2N902	2	NPND	Si	150	1000	45		6.0	h_{fe}:V_{ce}-5.0V	9-20	RAY
2N903	2	NPND	Si	150	1000	45		8.0	h_{fe}:V_{ce}-5.0V	18-40	RAY
2N904	2	NPND	Si	150	1000	45		11	h_{fe}:V_{ce}-5.0V	18-40	RAY
2N905	2	NPND	Si	150	1000	45		8.0	h_{fe}:V_{ce}-5.0V	36-88	RAY
2N906	2	NPND	Si	150	1000	45		13	h_{fe}:V_{ce}-5.0V	78-330	RAY
2N907	5	NPND	Si	150	1000	45	30	30	h_{FE}:I_C- 10ma	20-55	RAY
2N908	5	NPND	Si	150	1000	45	30	45	h_{FE}:I_C- 10ma	45-150	RAY
2N934	5	E	Ge	150	400	13		60†	h_{FE}:I_C-100ma	60	RCA
2N956	3	NPNPL	Si	500		75		200†	h_{FE}:I_C-150ma	100min	FSC
2N1131A	3	NPNMe	Si	750		60	40		h_{FE}:I_C-150ma	20-45	HUG
2N1132A	3	NPNMe	Si	750		60	40		h_{FE}:I_C-150ma	30-90	HUG
2N1616A	2	NPN	Si	85		60		2.0	h_{FE}:I_E-2.0A	40	SIL
2N1617A	2	NPN	Si	85		80		2.0	h_{FE}:I_E-2.0A	40	SIL
2N1618A	2	NPN	Si	85		100		2.0	h_{FE}:I_E-2.0A	40	SIL
2N1894	3	NPND	Si	85W	2.06	60	60		h_{FE}:I_C-1.0A	12-60	RAY
2N1895	3	NPND	Si	85W	2.06	80	80		h_{FE}:I_C-1.0A	12-60	RAY
2N1896	3	NPND	Si	85W	2.06	60	60		h_{FE}:I_C-1.0A	45-135	RAY
2N1897	3	NPND	Si	85W	2.06	80	80		h_{FE}:I_C-1.0A	45-135	RAY
2N1898	3	NPND	Si	85W	2.06	100	100		h_{FE}:I_C-1.0A	45-135	RAY
2N1905	3	D	Ge	50W	1.5	60		75Kc△	h_{FE}:I_C-1.0A	90	RCA
2N1906	3	D	Ge	50W	1.5	100		75Kc△	h_{FE}:I_C-5.0A	125	RCA
2N1954	5	PNPA	Ge	200	350	60	30		h_{FE}:I_C- 20ma	30-120	RAY
2N1955	5	PNPA	Ge	200	350	60	30		h_{FE}:I_C- 20ma	50-200	RAY
2N1956	5	PNPA	Ge	200	350	60	45		h_{FE}:I_C- 20ma	30-120	RAY
2N1957	5	PNPA	Ge	200	350	60	60		h_{FE}:I_C- 20ma	30-120	RAY
2N1970	3Ø	PNPA	Ge	150W	.50	100	50	.20	h_{FE}:I_C- 12A	17	DEL
2N1971	3Ø	PNPA	Ge	50W	1.5	80	40	.75	h_{FE}:I_C-2.0A	13	DEL
2N2018	3	NPND	Si	40W	.266	150	150	10#	h_{FE}:I_C-100ma	15min	TRA
2N2019	3	NPND	Si	40W	.266	200	200	10#	h_{FE}:I_C-100ma	15min	TRA
2N2020	3	NPND	Si	40W	.266	150	150	10#	h_{FE}:I_C-100ma	25min	TRA

TYPE NO.	USE (See Code Below)	TYPE (See Code Below)	MAT	Max. Ratings @ 25° C. P_C (mw)	DERATING °C/W	V_{CB}	V_{CE}	Typical Characteristics $f_{\alpha b}$ (mc)	GAIN PARAMETER And (Condition)	GAIN VALUE	MFR. See Code
AF114	4	PNPAD	Ge	50	.60	20	20	75†	PG at 100Mc	14db	RADF
AF115	4	PNPAD	Ge	50	.60	20	20	75†	PG at 100Mc	13db	RADF
AF116	4	PNPAD	Ge	50	.60	20	20	75†	PG at 10.7Mc	25db	RADF
AF117	4	PNPAD	Ge	50	.60	20	20	75†	PG at .45Mc	42db	RADF
AT/AF1	2	PNP	Ge	120		16		2.0	h_{fe}:I_e-1.0ma	60	ATLB
AT/AF2	2	PNP	Ge	120		16		2.0	h_{fe}:I_e-1.0ma	70	ATLB
AT/RF1	2	PNP	Ge	120		16		7.0	h_{fe}:I_e-1.0ma	90	ATLB
AT/RF2	2	PNP	Ge	120		16		15	h_{fe}:I_e-1.0ma	120	ATLB
AT/S13	2	PNP	Ge	120		16		9.0	h_{fe}:I_E- 15ma	100	ATLB
BFY10	4	NPND	Si	375	.40	45		50†Ø	PG at 35Mc	10db min	RADF
CK22B	2	PNPA	Ge	75	.80	35	12	1.2	h_{fe}:V_{ce}-6.0V	54-132	RAY
CK64B	2	PNPA	Ge	75	.80	45	29	.80	h_{fe}:V_{ce}-6.0V	13.5-33	RAY
CK65B	2	PNPA	Ge	75	.80	45	24	1.0	h_{fe}:V_{ce}-6.0V	27-66	RAY
CK66B	2	PNPA	Ge	75	.80	35	20	1.2	h_{fe}:V_{ce}-6.0V	54-132	RAY
CK67B	2	PNPA	Ge	75	.80	35	15	1.5	h_{fe}:V_{ce}-6.0V	108-264	RAY
CK419	2,5	NPND	Si	250	.54	50	40	10Ø	h_{FE}:I_C-5.0ma	9-22	RAY
CK420	2,5	NPND	Si	250	.54	50	35	10Ø	h_{FE}:I_C-5.0ma	18-44	RAY
CK421	2,5	NPND	Si	250	.54	50	30	10Ø	h_{FE}:I_C-5.0ma	36-88	RAY
CK422	2,5	NPND	Si	250	.54	50	35	10Ø	h_{FE}:I_C-5.0ma	9-44	RAY
CK474	2,4	NPND	Si	250	.54	50	40	10Ø	h_{fe}:V_{ce}-5.0V	9-22	RAY
CK475	2,4	NPND	Si	250	.54	50	35	10Ø	h_{fe}:V_{ce}-5.0V	18-44	RAY
CK476	2,4	NPND	Si	250	.54	50	30	10Ø	h_{fe}:V_{ce}-5.0V	36-88	RAY
CK477	2,4	NPND	Si	250	.54	50	35	10Ø	h_{fe}:V_{ce}-5.0V	9-44	RAY
GFT41	4	D	Ge	50	1000	8.0		150			TKD
GFT44/15E	4	D	Ge	50	1000	15		10			TKD
SFT232	2	A	Ge	450	130	40	30		h_{FE}:I_C-1.0A	40	CSF
SFT233	2	A	Ge	450	130	60	40		h_{FE}:I_C-1.0A	40	CSF
SFT259	5	NPNA	Ge	150	400	24	15	5.0#			CSF
SFT260	5	NPNA	Ge	150	400	24	15	9.0#			CSF
SFT261	5	NPNA	Ge	150	400	24	15	13#			CSF
SFT316	4	D	Ge	120	500	20		50#	h_{fe}:I_c-1.0ma	120	CSF
SFT358	4	D	Ge	120	500	20		70		150	CSF
XC161	2	PNPA	Ge	250	200	26	16		h_{FE}:I_c-400ma	72	AEIE
XC163	3	PNPA	Ge	750	65	26	16		h_{FE}:I_c-400ma	72	AEIE
XT100	2	PNPD	Ge	200		35	30	300†	h_{FE}:I_C-400ma	35	SPR

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COMPAGNIE GENERALE: 2N404

ELECTRONIC TRANSISTOR: 2N78A, 2N97, 2N98, 2N99, 2N207, 2N207A, 2N207B, 2N213, 2N213A, 2N214, 2N240, 2N358, 2N377A, 2N385A, 2N388A, 2N404A, 2N414B, 2N414C, 2N467, 2N504, 2N505, 2N570, 2N571, 2N572, 2N631, 2N634A, 2N635A, 2N636A. 2N650A, 2N652, 2N652A, 2N655, 2N1018, 2N1124, 2N1125, 2N1128, 2N1129, 2N1130, 2N1171, 2N1191, 2N1192, 2N1193, 2N1265, 2N1266, 2N1273, 2N1274, 2N1298, 2N1306 thru 2N1309, 2N1313, 2N1378 thru 2N1382, 2N1408, 2N1413 thru 2N1416, 2N1471, 2N1473, 2N1478, 2N1605, 2N1624

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HUGHES: 2N706, 2N706A, 2N707, 2N753, 2N1131, 2N1132

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SPRAGUE: 2N768, 2N769, 2N1204, 2N1494, 2N1676, 2N1677

TRANSITRON: 2N706, 2N717 thru 2N720, 2N730, 2N731, 2N738, 2N739, 2N740, 2N909, 2N1047 thru 2N1050, 2N1047A thru 2N1050A, 2N1131, 2N1132, 2N1252, 2N1253, 2N1420, 2N1564, 2N1565, 2N1566, 2N1572, 2N1573, 2N1574

NOTATIONS

Under Use

1- Low power a-f equal to or less than 50 mw
2- Medium power a-f 50 mw and equal to or less than 500 mw
3- Power>500 mw
4- r-f/i-f
5- Switching and Computer
6- Low Noise
7- Photo
8- Mixer
9- Local Oscillator
☑- Revised Spec.
10- Chopper
11- Matched Pair
12- Video Amplifier
13- TV Sync. Separator
FLD—Field Effect

Under Type

A- Alloyed
D- Diffused or Drift
E- Epitaxial Mesa
F- Fused
G- Grown
H- Hook Collector
M- Microalloy
PL- Planar
Me- Mesa
O- Other
S- Surface Barrier
UNI - Unijunction Transistor
Y - Symmetrical
$ - Tetrode

Under Gain Value

Ø - Pulsed

Under fab

* - Maximum Frequency
# - Figure of Merit
△ - $f_{\alpha e}$
Ø - Minimum
† - f_T (Gain Bandwidth Product)
☑ - f_{os} max. (Max. freq. of oscillation)

Under Derating

Ø - Infinite heat sink

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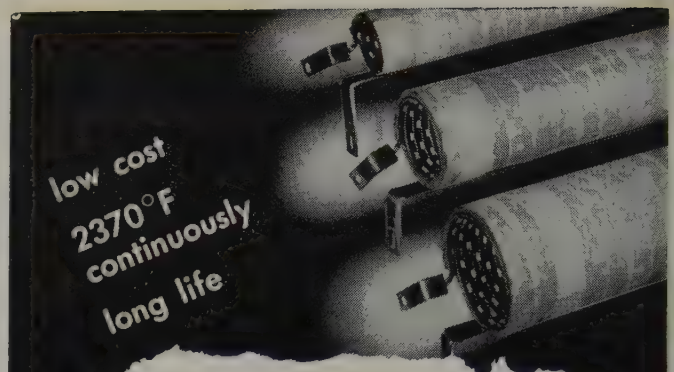

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World renowned Kanthal A-1 alloy (Fe, Cr, Co, Al) ceramic embedded in six, standard, ready-to-mount sizes for intermittent temperatures to 2460°F:

Type No.	Rating Max.	Volts Max.	Resistance	Inside Dia.	*Heating Length	List Price
REH-4-30	800 W.	15	0.26	1-9/16"	7-7/8"	$32.94
REH-4-60	1200 W.	29	0.65	1-9/16"	19-3/4"	$54.32
REH-7-30	1200 W.	24	0.44	2-3/4"	7-7/8"	$38.21
REH-7-60	1800 W.	46	1.05	2-3/4"	19-3/4"	$73.47
REH-10-30	1800 W.	34	0.59	4"	7-7/8"	$39.61
REH-10-60	2500 W.	63	1.44	4"	19-3/4"	$76.48

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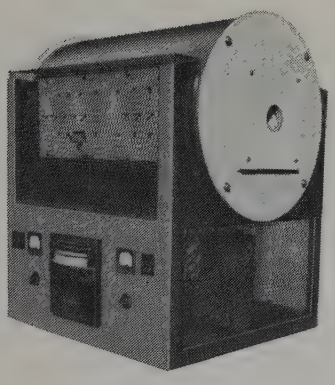

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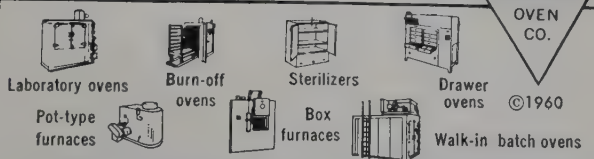
For additional information, write today for free bulletin 206-5L4.

DESPATCH OVEN CO.



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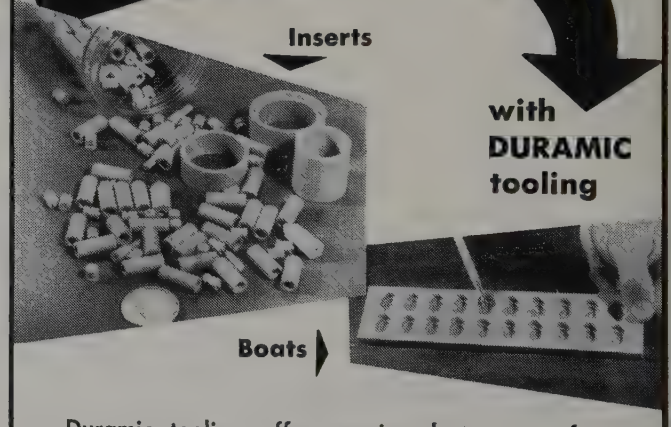
DESPATCH OVEN CO. 619 S.E. 8th St., Minneapolis 14, Minn.

Circle No. 21 on Reader Service Card

INCREASE YOUR YIELD



Duramic tooling offers semiconductor manufacturers a proven non-wetting alloying and soldering boat material, with greater wear resistance, exceptional dimensional stability, and cleanliness.

Ask for Bulletin 117...Send prints for quotation.

DURAMIC PRODUCTS, INC.

Dept. SP-7

426 Commercial Avenue, Palisades Park, N. J. Windsor 7-0310

Circle No. 22 on Reader Service Card

Market News *(from page 39)*

Expansion

A new plant for the production of welded components for the electrical-electronics industry was formally opened in Warren, Pa., by the Parts Division of Sylvania Electric Products Inc. The plant produces automatic leads and custom welded assemblies for such electrical-electronic product lines as receiving tubes, incandescent and other types of lamps, semiconductors, and resistors. The great demand for transistors and other semiconductor devices, particularly, has been responsible for the growth of Sylvania's weld operation over the past several years. Some of the new machines, designed and built in the division's own equipment development plant, are capable of producing more than one million of a certain type of welded assemblies each week.

The General Electric Co., Rectifier Components Department, Auburn, N.Y., manufacturer of semiconductor rectifiers is planning to construct an addition to their local plant, which will enclose over 70,000 square feet, costing an estimated $1,700,000. Ground will be broken in late summer.

A new laboratory for testing semiconductor devices, for both manufacturers and large volume users, has been established by Wallson Associates, Inc., Elizabeth, New Jersey. Initially, the firm will devote about 4,800 square feet to the testing of transistors, diodes, and power rectifiers. Provisions have been made for further expansion if required and plans are being made for the eventual establishment of a West Coast manufacturing and testing facility. The laboratory will be run by the company's engineering staff.

New Firms

Automation Alloys, Inc., a subsidiary of Permonite Manufacturing Company of Chicago, Illinois was formed a few months ago with Arun K. Dube and Herbert Fass as principals. The firm has created sealed floor to ceiling chambers for each major alloy group. Cross contamination of elements is minimized. Water flow has been converted to non-metallic piping, and water of one million ohms to two million ohms resistivity is used in production. For laboratory purposes, the water used approaches 16 to 18 million Ohms. Air pumped into production chambers, is filtered through semi-micro fiberglass filters. They are utilizing vibration chill casting technique for greater uniformity and homogeneity of cast alloys, and are using separate rolling mills and punch presses in each chamber. The dies and the rolls are never used for more than one metal, according to the company. The firm is setting up cladding facilities and expects to be supplying accurate inlays, overlays, single clad and sandwich clad base tabs and preforms at an early date. They already are in full scale production of preforms.

The Vacuum Tweezer Company has been formed to do research, development and manufacture of Parts Handling Equipment for the Semiconductor and Miniaturization Industries. The Company is already in operation at 1780 St. Georges Avenue, Rahway, New Jersey. The company will center its activity in the area of vacuum pickup instruments.

ERRATA

In the industry report appearing in the June 1961 issue on page 45, two major suppliers were omitted from the silicon category by typographical error. Both Dow-Corning and Monsanto Chemical should have appeared therein.

REDUCE COSTLY KERF LOSSES

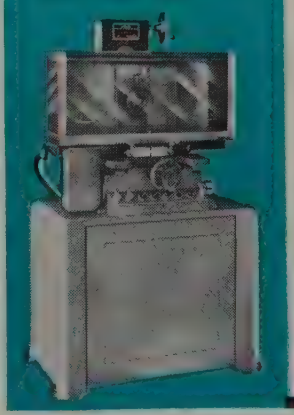
in slicing semiconductor material...

Now . . . switch to 3½" diameter diamond wheels to slice 1" diameter crystals on

Micromech **WAFERING MACHINES**

featuring the *NEW* **TYPE 2 CARTRIDGE SPINDLE**

Micromech's newly-designed Type 2 Cartridge Spindle permits the use of thinner, smaller-diameter diamond wheels for slicing germanium and silicon. Provides top wafering efficiency with wheels of *all* sizes, too!



This specially-engineered spindle mounts a 3½" diamond wheel in place of the usual 5" wheel to give from 40% to 100% more slices per 1" diam. crystal . . . reduce kerf loss by 28% to 47%!

Micromech's thinner blades in 3½" diameter size can save from .004" to .009" per slice . . . add up to savings of $200.00 a day!

Moreover, the 3½" wheel allows cutting speeds up to 3" per minute . . . increasing production while decreasing loss of material.

Type 2 Cartridge Spindle is now standard on Micromech hydraulic automatic wafering machines. Write today for detailed information.

FOR QUALITY CONTROL —

Micromech Optical Orientation System

This easy-to-operate system produces accurate visual patterns for identification of principal planes of any single crystal material. No interpretation or correlation data needed. Operator need not be technically trained. Transference of aligned crystal from orientation base to wafering machine table allows accurate cutting of crystal on plane to which it was aligned. Self-contained low-cost unit requires only 2 sq. ft. of table space.

Micromech Diamond Wheels

Micromech stocks 3½" diamond wheels for the economical and fast slicing of all semiconductor materials.

Wheels also available in other popular and odd sizes, DIT and DITRS types. Precision manufacture to close tolerances assures accuracy of cut and long life.

Send for free technical data

MICROMECH MANUFACTURING CORP.

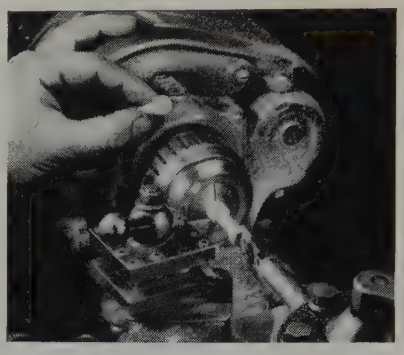
A Division of Sanford Manufacturing Corp.

695 Rahway Avenue — Union, New Jersey — MUrdock 7-3200

Circle No. 33 on Reader Service Card

Problem: "On spec" yield of semi-conductor components drop as much as 40% within 50 cycles when using *graphite* jigs

Solution: **BORON NITRIDE**
for semi-conductor jigs



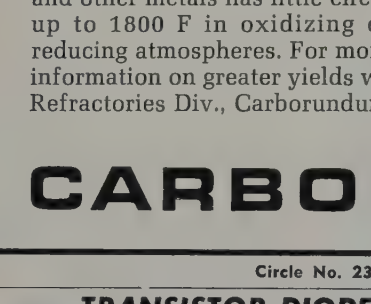
Boron nitride machines easily to close tolerances, resists chipping and retains internal jig details. It holds dimensions, has excellent release characteristics and is non-toxic.

Contact with silicon, germanium, indium, antimony, lead and other metals has little effect up to 1800 F in oxidizing or reducing atmospheres. For more information on greater yields with boron nitride, write Latrobe Plant, Refractories Div., Carborundum Co., Latrobe, Pa.

CARBORUNDUM®

Circle No. 23 on Reader Service Card

TRANSISTOR-DIODE
TESTERS
Laboratory Accuracy
Production Versatility



Accurate for use in precision laboratory analysis of semiconductor devices, Trans Electronics Transistor and Diode Testers have the versatility and ruggedness for use by unskilled operators in quantity testing. Types available: Voltage-regulated, with 6 current ranges between 10 and 3000 milliamps; 2 voltage ranges: 0-1000 and 0-3000 millivolts; remote load sensing. Forward-Current and Reverse-Current, Saturation-Voltage (E_s-Ib) types available. Two classes of Forward Testers provide ranges of 0-3 amps, and 0-3 volts; Back Testers, 0-1000 and 0-3000 volts, each with 1 milliamp current capability. Meter ranges: 3 milli-microamps to 1 milliamp.

- Keyboard Metering
- Mirrorback (1%) Meter
- Meter in Electronic Metering Circuit

INQUIRE ABOUT OTHER TRANSISTOR AND DIODE EQUIPMENT OFFERED BY:

TRANS ELECTRONICS, Inc.
8910 Winnetka Avenue
Northridge, California
Diamond 1-4400

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OUR CLIENTS

are seeking to purchase firms in all segments of the electronic industry. If your company is interested in negotiating toward that end, contact us immediately. All correspondence kept in strictest confidence.

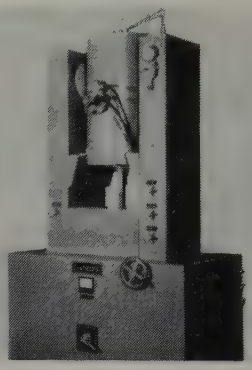
ELINEX

SEMICONDUCTOR PRODUCTS
Box 98 SCP
300 West 43rd St.,
New York 36, N. Y.

Circle No. 98 on Reader Service Card

New Products

High Temperature Furnace



A new high temperature vertical graphite element furnace, Type TRV25-518, for operation to 5000°F (2750°C) has been added to its line of equipment for production of semiconductors, solid state and other electronic devices according to an announcement by Lindberg Engineering Company. The graphite element is 5" I.D. by 18" high with a 6" effective work height at plus or minus 25°F. The bottom loading graphite work hearth is 4¼" O.D. and is raised and lowered by means of a hand wheel.

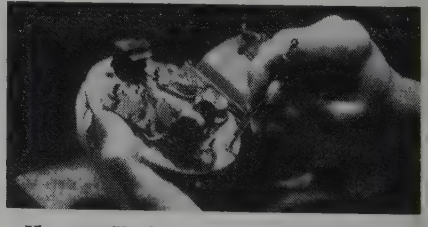
Circle 101 on Reader Service Card

Scopemobile Cart

Tektronix Type 200-Series Scope-Mobile Carts provide a convenient mobile support for oscilloscopes or auxiliary equipment. They feature an easily-adjustable tray which can be tilt-locked in any one of nine positions. They also feature an optional plug-in carrier which can hold additional plug-ins. Dimensions for Types 201 and 202 are approximately 35" high by 17½" wide by 27" deep. Weight is 35 pounds.

Circle 103 on Reader Service Card

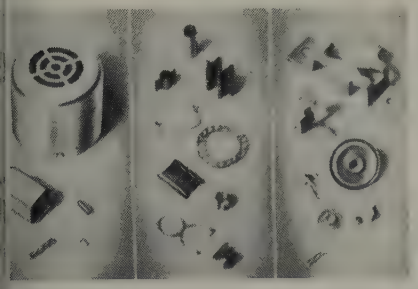
Precision Deburring Set



Hunter Tools is offering a precision Deburring Set that meets the exacting requirements of the miniature electronic market. The set, which comes in a small plastic kit, consists of six 3½" tools offering a different size deburring tool at each end. The smallest size in the set is .020 and the largest is .225. It is extremely useful around electronic work where burred surfaces can scratch delicate wires.

Circle 104 on Reader Service Card

ampings and Deep Drawn Parts



Deep drawn parts up to eight" in iameter, stampings up to 12" in width, nd wire and strip parts made on multi-lide machines are now manufactured by ohnson & Hoffman Manufacturing Corp. he maximum depth of the company's eep drawn materials has been increased o 4" (from approximately 2") and the naximum diameter to 8" (from approxi-nately 2"). Maximum thickness remains /16". On metal stampings, maximum hickness has been increased to .250" from .045") and maximum width to 12" from 4"). Multi-slide wire parts are sup-lied in diameters from .005 to .188" and trip parts from .005" to .031" thick in idths up to 2".

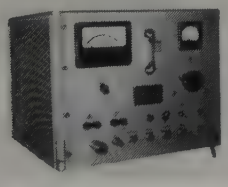
Circle 105 on Reader Service Card

Conveyorized Controlled Atmosphere urnace

BTU Engineering Corporation has de-eloped a standard, controlled atmos-here furnace Transheat Model TS-1X18, which permits continuous Flux-Free oldering or brazing, yielding uniform igh quality, and high volume at greatly educed cost. The gas control system of he furnace offers complete safety and ail safe provisions for the handling of ydrogen. Purity of the atmosphere with-n the furnace can be maintained to less han 1 part per 1 million.

Circle 131 on Reader Service Card

Calorimeter



A new Calorimeter which is capable of measuring any power that can be transferred to a circulating fluid is announced by Electro Impulse Laboratory, Inc. It is direct reading and can be calibrated in watts, BTU's per minute, horse power or foot-pounds per minute. Models are available for measuring ranges from .1 BTU to 3000 BTU's per minute.

Circle 107 on Reader Service Card

Solar Cell

A new commercially available type of silicon solar cell which is electrically opposite from the company's regular line of "P-N" cells was announced by the Semiconductor Division of Hoffman Electronics Corporation. In the new N-P cells the N type "skin" is formed by diffusing phosphorous onto P type silicon. Type #N120CG-10 is now available in sample quantities at an electrical conversion efficiency of 10% or greater.

Circle 133 on Reader Service Card

high speed automatic dice gaging and sorting for the semi-conductor industry

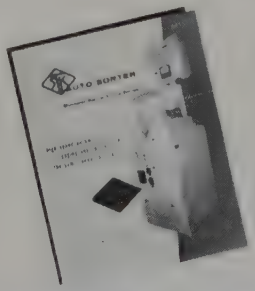
80% SAVINGS IN LABOR COSTS!

TSK AUTO-SORTER

Let a Techni-Rite sales engineer show you how to reduce **your** dice/wafer sorting costs by **eliminating completely up to 4 out of 5 inspection and sorting personnel.**

The new TSK Auto-Sorter is a dependable, high-speed production unit which automatically gages and sorts germanium or silicon dice into various categories . . . faster, and with far greater accuracy, than human hands. One transistor manufacturer reduced his work force from 30 to 6 virtually overnight!

Nearly 200 TSK Auto-Sorters are now in constant service. Factory-trained installation and service experts . . . and a complete inventory of replacement parts . . . are on hand at all times.



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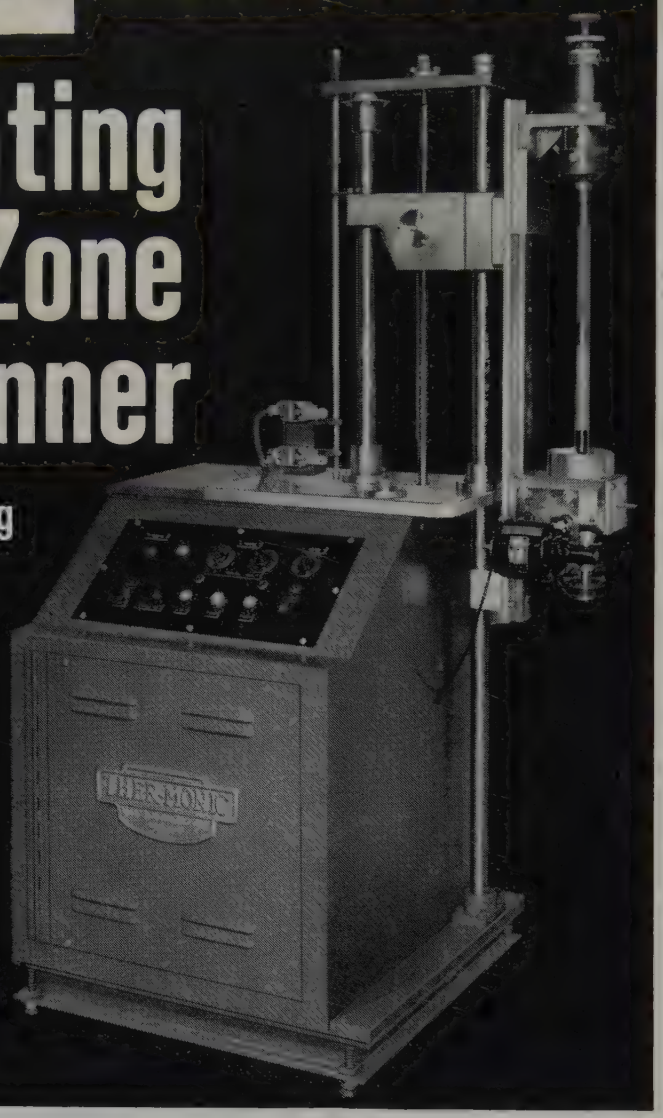
techni-rite ELECTRONICS INCORPORATED

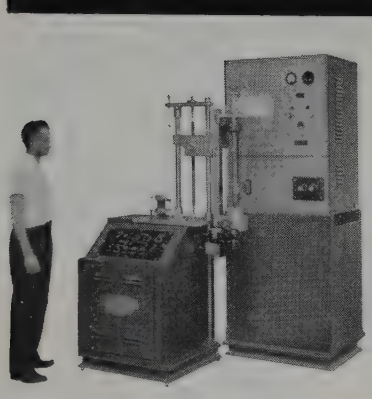
67 Centerville Road • Warwick, Rhode Island • REgent 7-2000

Circle No. 29 on Reader Service Card

New! THER-MONIC Floating Zone Scanner

for refining and crystal growing!





Ther-Monic offers you precision equipment possessing an outstanding degree of flexibility of control in refining highest purity semi-conductors and various other metals.

Ther-Monic also manufactures production machinery for many other operations in the semi-conductor industry.

Ther-Monic R.F. generators – single and dual frequency – are available from 1 KW to 125 KW output.

Several thousand induction heating installations in numerous industries attest to the efficiency and economy of Ther-Monic equipment.

Write for New 56-page Catalog FZ

INDUCTION HEATING CORPORATION

181 WYTHE AVENUE, BROOKLYN 11, N.Y.

Largest Producers of Electronic Heat Treating Equipment

Subsidiary of Hathaway Instruments, Inc.

Circle No. 25 on Reader Service Card

Photovoltaic Detector

The Lansdale Division of Philco Corporation has announced a gallium arsenide photovoltaic detector specifically designed for small signal use. A TO-18 case used commonly as a transistor package provides size reduction and ruggedness. The single crystal device, GAU-401, provides high sensitivity for both visible and near-infrared radiation detection. The detector is designed for the 0.4 to 0.9 micron region, having a peak sensitivity at 0.85 microns. Operation up to 120°C shows no loss in sensitivity, according to the company.

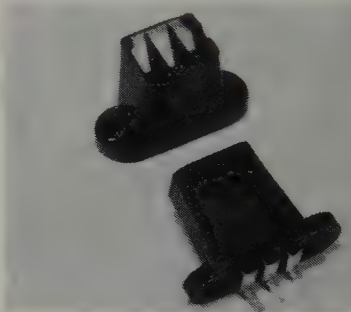
Circle 102 on Reader Service Card

Pigtail Grabber

A semi-automatic fixture, that simultaneously seizes both pigtails of diodes, transistors, capacitors, and resistors, makes secure low-resistance electric-test connections with no danger of bending the leads or breaking them off is announced by Precision Metal Products Co. The gripping jaws work separately to compensate automatically for differences in wire size or position, and the spring tension on the jaws can be individually adjusted. The fixture requires bench space only 3¼ x 3¼".

Circle 115 on Reader Service Card

High Temperature Miniature Transistor Test Socket



Major advantages of Atlantis Electronics Corp., "Test Socket" are: reversible contacts, quickly changed to compensate for wear; elimination of point contact to transistor leads; used in conjunction with AMP parallel connector terminal #34130, which eliminates soldering; and a channel for foreign material to pass through. Leakage, at 500 volts room temperature, is less than 1 millimicroamp; elimination of porosity. Temperature Ratings: Socket TS-187-300°C Socket TS-187-A-1500°C.

Circle 129 on Reader Service Card

Measuring Microscope

Opto-Metric Tools Multi-Purpose Microscope, the Optotron, combines a coordinate Measuring, a Toolmaker and a Metallurgical Microscope in one compact instrument. It is equipped with interchangeable Leitz Optics throughout, including a triple nosepiece for 30x, 100x and 400x magnification, but these may be varied to suit individual requirements. The measuring stage has a range of 1" x 1" by direct reading micrometers in .0001". Coarse and fine focusing is available; also a dial gage for depth measurements in .0001".

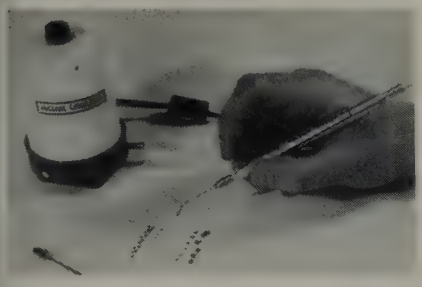
Circle 118 on Reader Service Card

Sub-Assembled Semiconductor Bases

Ready-to-weld copper semiconductor bases, with integral steel rings already brazed in place, are being supplied in the full-hard condition by Standard Pressed Steel Co. The new base material is a hardenable copper alloy which possesses electrical and thermal conductivity properties comparable to those of oxygen-free copper. The big obstacle the SPS base overcomes is the high temperature of brazing operations. They are finished in various heat-resistant platings, silver, dull nickel or bright nickel. In addition to new standard 7/16, 9/16 and 11/16 across-flats hexagon sizes, bases will also be made to customer specifications.

Circle 127 on Reader Service Card

Vacuum Tweezer System



The Vacuum Tweezer Company System V-100 is a precision miniature parts handling system, utilizing vacuum energy, specifically designed for use in the handling of tiny, delicate components. It is a complete self-contained and portable system. The basic assembly consists of a small, adjustable and patented electromagnetic vacuum generator approved by U.L., a vacuum pencil and several vacuum pickup tips. Fingertip control of vacuum permits operator to quickly pick-up, hold, sort, carry or deposit miniature parts without causing damage or defects.

Circle 124 on Reader Service Card

Block Valves for Vacuum Systems

A series of block valves for mounting in various types of industrial high vacuum systems, having a common bellows seal assembly for sizes less than 1", factory leak-tested and providing for maximum gas flow within compact design, are announced by NRC Equipment Corporation. Machined from solid brass square stock, the porosity-free valves are available with in-line or angle configurations for soldered or screwed connections in sizes from ¼" to 1½".

Circle 109 on Reader Service Card

Clad Metal Combination

A Tin Clad Nickel ribbon created for use as a substitute for Platinum Whisker wire in the manufacture of diodes, has recently been developed and introduced by Composite Industrial Metals. CIM's new Cladding Process enables wrought metals to be bonded together in the solid state without the use of bonding agents at the inter-faces. The result is an ultra pure Clad Metal combination that increases production yields for semiconductor devices.

Circle 121 on Reader Service Card

NEW from TI

Measures bulk or slice material

Adaptable for use with other probes

Compact and portable

Texas Instruments new, fully-transistorized Model 635 Crystal ρ Meter is the first portable, a-c instrument designed to measure both bulk and slice resistivity of semiconductor crystals. More accurate and stable readings are achieved by reducing the effect of noise and stray pick-up.

The TI Crystal Resistivity Meter uses a 1000-cycle, square-wave, constant-current source with superimposed d-c bias on probe points to reduce point contact resistance. Ten ranges, selectable by front panel range switch, measure resistivities from .01 to 300 ohm-centimeters, full-scale.

A slice adapter measures resistivity of slices from .007 to .037 inch in thickness. Precision jeweled TI probes are available for measurements of germanium or silicon. The meter can be calibrated for use with other probes having contact spacings from .030 to .080 inch.

Write for complete information.

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ETCHING

Don Juan never had it so good . . . semiconductor manufacturers actually ask us if they can come see our etchings!

Our etching of Ge and Si slices and dice removes surface damage, reduces to accurate size, and provides the finish you want.

While our etchings won't help you lure the blushing maiden to your den, our happy clients tell us the quality of our work attracts the attention of many non-blushing purchasing agents.

Next time you're in the area, come on over and we'll show you what our etchings look like!

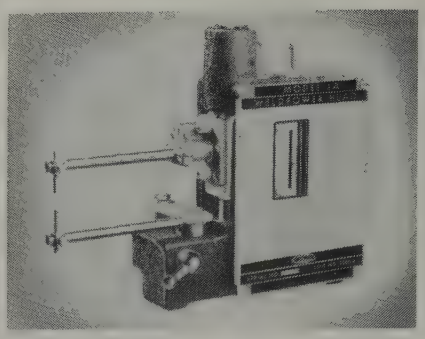
slicing, lapping, etching, dicing, sizing, special shapes.

SEMICONDUCTOR SPECIALTIES CORP.

252 Garibaldi Ave., Lodi, N. J.
PRescott 3-6933

Circle No. 26 on Reader Service Card

Welding Head



Rapid, precise welding of subminiature electrical and mechanical parts is accomplished by an improved compact welding head developed by Raytheon Company's Commercial Apparatus & Systems Division. Designed principally for manufacturers of semiconductors, electronic equipment and modules, the Weldpower Model JA Head features an extremely fast forging force and adjustable steel ball bushings. Weighing only nine pounds, the unit's forging force range is 1 to 10 pounds. Electrode diameter is ⅛" and the maximum stroke is ¾".

Circle 111 on Reader Service Card

Dust-Free Cabinet

A dust-free cabinet moulded from distortion-free plexiglass of optical clarity is announced by Gerwen Electronics. The filter system removes 99.97% of all particles of 0.3 micron size, is absolute for particles over 0.3 microns. The blower is capable of sustaining air flow of 50 cfm to create pressure differential of ½ lb. per sq. ft. between cabinet interior and exterior air. An under-the-hood terminal board is provided for test voltages.

Circle 114 on Reader Service Card

Silicon Controlled Rectifiers

A new line of studless, low current Silicon Controlled Rectifiers in double-ended housing has been introduced by the General Electric Company. The new devices in which the stud is replaced by a single lead will accommodate high current loads without heat sinks. The double-ended mechanical design permits point to point wiring in a wide variety of circuits. D-C load current rating is 1.1 Amps. The seven models have been assigned JEDEC designations of 2N1929 through 2N1935. They differ by repetitive peak reverse voltage ratings which range from 25 volts for the 2N1929 to 300 volts for the 2N1935.

Circle 100 on Reader Service Card

High Purity Gold Electroplate

An extra high purity gold electroplating process, Temperex HD, is said to meet or surpass the most exacting finishing specifications required by manufacturers of transistors and other electronic components. Developed by Sel-Rex Corporation, the new process reportedly produces deposits of 99.99% purity. According to the company, electroforms to 30-thousandths of an inch are easily produced under commercial operating conditions. The electroplate is also reported to exceed the requirements of such standard electronic product-acceptance tests as exposure to 550°C/10 minutes; 300°C/96 hours in air.

Circle 137 on Reader Service Card

NEW SERVICE NOW AVAILABLE

SEMICONDUCTOR PRODUCTS is making a new source of information available to all firms interested in being kept up to date on materials or equipment for producing semiconductor devices. If you wish to receive all new literature on silicon, germanium, chemicals, machinery, or other such materials, circle #99 on the reader-service card. Your name will be placed on a special list which will be forwarded to all such suppliers. As these suppliers have news available in their field, you'll be notified by them immediately. This service is restricted to firms manufacturing semiconductor devices or firms contemplating entering into production within 120 days.

BACK ISSUES

1.00 Each

1958—Jan/Feb; March/April; May/June; Nov/Dec.

1959—Dec.

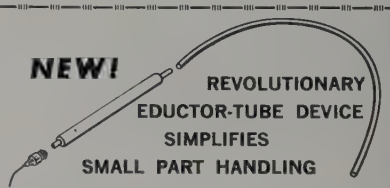
1960—March, May, June, July, Aug., Sept., Nov.

1961—Feb., Mar., May

SEMICONDUCTOR PRODUCTS

Back Issue Dept.

300 W. 43 St. New York, N. Y.



NEW! REVOLUTIONARY EDUCTOR-TUBE DEVICE SIMPLIFIES SMALL PART HANDLING

Unique Penfield Pickup uses 1-2 psi of air or inert nitrogen to pick up and release minute particles. Negative pressure created at hypodermic needle point is sufficient to hold germanium, silicon, other minuscule parts. To release the held particle, operator merely finger-stops an orifice in the eductor-tube. Use of Penfield Pickups eliminates all foot switches, solenoids, costly vacuum equipment, troublesome plugging problems. Send for trial sample ($10.75 each, Postage Paid) and see for yourself.

Penfield Manufacturing Co., Inc.
Telephone: BEverly 5-1694
19Y High School Ave., Meriden, Conn.

Serving the Electronics Industry with Ion Exchange Systems • Filters • Weir Washers • Parts Baskets

Circle No. 27 on Reader Service Card

Epoxy Pellets

Epoxy Products, Inc., has prepared epoxy bonding material in easy-to-handle pellets which eliminate difficulty in mixing and metering, and skin irritation. Epoxy pellets will bond practically any kind of material to any other kind. Shear strength of a steel to steel bond is 4700 psi. Pellet size is tailored to each bonding application so that when the pellet melts it provides exactly the right amount of adhesive for the job. Curing temperature can be varied from 85°C for bonding heat-sensitive components to 250°C for a fast cure bond.

Circle 106 on Reader Service Card

Thermoelectric Generator

The commercial availability of an eight-watt thermoelectric power generator for industrial field applications has been announced by Texas Instruments Incorporated. The units contain no moving parts. They will operate from natural gas, propane or butane and are primarily designed for remote unattended field instrumentation No housing or special enclosure is required as the generator's burner is completely free from wind blowout. The generators weigh 65 pounds and are 12" wide by 17" high. They can also be adapted to use any combustible fuel, waste heat and steam or solar heat.

Circle 126 on Reader Service Card

Silicon Rectifiers

Slater Electric Inc., announces a line of miniature hermetically sealed silicon rectifiers. The internal "junction connector lead," has been eliminated. The "Trim-Line" series presently covers current ranges up to 1.5 amperes at PIV Ratings up to 1000 volts. The body length of the device is .250" and has an OD of .225"; it mounts with axial wire leads. Also included in the line is a press fit hermetically sealed rectifier conservatively rated for 50 amperes at 25°C case temperature. These devices are .625 maximum OD and have a maximum body length of .380".

Circle 112 on Reader Service Card

Transistor Radiator/Retainers

The Birtcher Corporation/Industrial Division has developed a new combination transistor heat radiator and retainer called "Kool-Tainer" and offered in two sizes, designated 3AL-725 and 3AL-728. The devices reduce heat up to 25% owing to increased surface area provided by their multifin design. Sides of mounting holes are slotted to accept a wide variance of case diameters from 0.310-0.325" and 0.475-0.490" for all the more important transistor package sizes

Circle 134 on Reader Service Card

Degassing/Oxidation Furnace

A new furnace, developed by BTU Engineering Corp., and designated Tandem Transheat, combines decarburization (degassing) and oxidation of Kovar into one continuous operation, prior to use in glass-to-metal seals. The advantages are the prevention of contamination after degassing and the creation of a highly uniform and reliable oxide coating on the Kovar which assures a proper seal with uniform production results. In addition to increasing the quality and yield factors, this furnace also reduces production costs by eliminating double handling, according to the company.

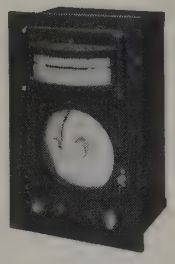
Circle 113 on Reader Service Card

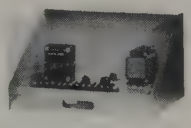
SPECIFIED
FOR MAKING SEMI-CONDUCTORS

Part of diffusion furnace room, Hoffman Electronics Corporation, El Monte, California. Process is one step in critical manufacture of silicon solar cells.

Gardsman by WEST

Model JSBG Stepless Program Controllers





Semi-conductors are grown by a highly integrated process, involving time-temperature control. Only the most precise control delivers the required quality, uniformity, efficiency.

Leading producers of semi-conductors find best results from the market's most compact, integrated Stepless Program Controller: by West. This unit infinitely modulates heater power *and* coordinates time-and-temperature control for even the most unstable systems.

Also available: models combining Gardsman off-on, proportioning or 3-position controllers with programming. All are *tubeless* and noted for minimum maintenance and operating requirements. Ask your West representative or write for Bulletin JSB and JG.

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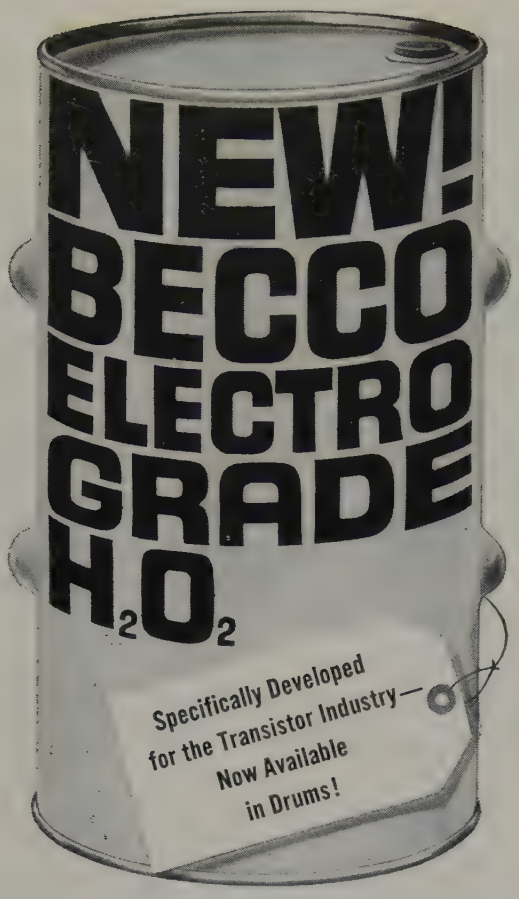
the trend is to WEST

Circle No. 31 on Reader Service Card



—And Becco will work with you to help you design the system best suited to realize the economies—and quality standardization—inherent in bulk shipments.

Here's a new, stabilized 30% Hydrogen Peroxide, specifically developed for transistor etching—Becco Electro Grade H_2O_2, with pH value of 3.0 to 3.5. Made from pure electrolytic H_2O_2, this new peroxide is available in 30- and 55-gallon polyethylene drums to save you many dollars!

What's more, Becco engineers will work with you to help you design a closed system, to guard against impurities. This means you get all the economies of bulk shipments...and assurance of a pure product at the same time. Whatever your needs, rely on Becco, *the* specialist in Hydrogen Peroxide for over 36 years!

Becco Electro Grade H_2O_2 is available now from shipping centers strategically located throughout the country. There's one near you. Why not take advantage of it?

Mail coupon for full information on Becco Electro Grade Hydrogen Peroxide.

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New York 17, N.Y.

Circle No. 32 on Reader Service Card

Industry News . . .

CONFERENCE CALENDAR

The Following August 1961 Meetings Are Scheduled:

Aug 16-18 2nd International Electronic Circuit Packaging Symposium, University of Colorado, Boulder, Colo. For Information: U. of C., Dept. of Electrical Engng.

Aug 22-25 WESCON (Western Electronics Show & Conference), Cow Palace, San Francisco, Cal. Sponsored by LA & SF Sections, WEMA, and IRE 7th Region. For Information: E. W. Herold, c/o WESCON, 701 Welch Rd., Palo Alto, Cal.

Aug 23-25 Pacific General Meeting, AIEE, Hotel Utah, Salt Lake City, Utah.

Aug 30-Sept 1 3rd Annual AIME Semiconductor Metallurgy Conference, Ambassador Hotel, Los Angeles. For Information: W. V. Wright, Electro-Optical Systems, Inc., 125 N. Vinedo Ave., Pasadena, Cal.

A series of six seminars during WESCON in San Francisco will be conducted by Pacific Semiconductors, Inc., according to Dr. Harper Q. North, PSI president. The two-hour sessions will be on subjects tentatively titled "Solid State Frequency Multiplier/Transistor Combinations in the UHF Region;" "All Transistorized Communications Circuitry;" "Computer Design;" "The Laminar Approach to the Universal Diode;" "Practical Aspects of Microminiaturization Techniques;" and "Reliability—Not a Word but a Discipline." Scheduled at 2 pm August 22, 10 am and 2 pm August 23 and 24 and 10 am August 25, the seminars will be held in the Borgia Room, St. Francis Hotel, and will be conducted by technical teams selected from various PSI divisions.

Thermoelectric refrigeration, heating, and power generation will become a booming industry by 1965, with annual sales reaching over $425 million. By 1970 annual sales will probably reach $3 billion. This is the prediction made by Dr. Robert A. Bernoff, director of research, Materials Electronic Products Corp., Trenton, N.J. Dr. Bernoff said, "Thermoelectrics will have a good part of the industrial and military markets and will radically change the consumer electric refrigerator-appliance field." According to Dr. Bernoff, thermoelectric cooling is practical now for small system consumer applications such as portable refrigerators, dehumidifiers, water coolers, and refrigerated serving tables. He says further that typical household applications by 1965 will include thermeolectric kitchens with distributed cooling in refrigerated drawers, table-top chilling and warming of dishes. He looks for these industrial applications by 1965: Aircraft and truck cooling, cooling for industrial motors, and refrigeration for vending machines. Military expenditures for thermoelectrics may reach $100 million annually by 1965.

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Circle No. 28 on Reader Service Card

RESEARCH AND DEVELOPMENT

Wafer-thin "solar-sandwiches," designed to convert the ın's energy to electrical power for space vehicles, are ow being developed for the U.S. Air Force by General ıtomic Division of General Dynamics. The new-concept olar power producer, which consists of a large number f tiny thermoelectric elements placed between two thin ıetallic sheets, is expected to have marked weight and ost advantages over present solar cell systems in provid- ng auxiliary power for space vehicles. The panels are eing developed under a study contract awarded by the Air Force's Aeronautical Systems Division at Wright-Patterson Air Force Base, Ohio.

As envisioned by General Atomic, the light-weight ower generating system would consist of a number of hese thermoelectric panels (about one-tenth of an inch hick), joined together to form sheets that would be folded ıp for launching, and then extended once the vehicle is n space to collect and convert the sun's energy into elec- ricity.

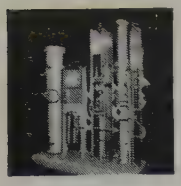
Dr. Robert W. Pidd, manager of General Atomic's pro- gram for the direct conversion of heat to electricity, said hat in the range of a few watts to several kilowatts, the concept shows promise of being both lighter and cheaper han any other type of auxiliary power generating system with similar output. For example, he said, a one kilowatt generator designed for operation near Venus might weigh only 20 pounds, while a one kilowatt generator for opera- tion near Mars might weigh about 80 pounds. Generators with lower power ratings would have proportionately smaller weights.

The panels differ from photoelectric solar cells in that they first convert the sun's energy to heat and then to electricity. Solar cells convert sunlight directly to electricity. The thermoelectric elements, made of a semiconductor material, are sandwiched between two specially treated metallic sheets, a collector and a radiator. The collector will convert solar energy to heat, which it will pass to the thermoelectric elements. These in turn, will convert the heat to electricity, which may then be withdrawn by completing a circuit across the collector and radiatior. The radiator will reject waste heat to space.

The possibility of using direct current for transmission of electric energy within the next quarter of a century was raised at the Summer General Meeting of the American Institute of Electrical Engineers. It may be that for transmission, "direct current, which was the dream of Steinmetz many decades ago, will come into its own," R. C. Mildner and John J. Grebe, of the Dow Chemical Company, Midland, Mich., told an AIEE insulation symposium in a technical paper titled, "Objectives for Overcoming Temperature and Electrical Stress Barriers of E.H.V. Cable Insulation Through Molecular Design." "In Europe experience is being gained in the operation of the d-c transmission techniques that have been developed, and it may be that solid-state rectifiers, based on the super-purity silicon which is coming into ever-increasing production, will make their contributions in this field."

Demineralizing Equipment NEWS

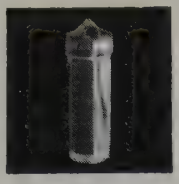
from Penfield



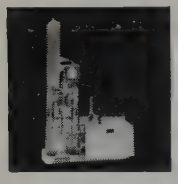
Fully "Packaged" System Supplies 125-150 GPH of 18 Megohm Water

Penfield's new S-150 Demineralizing System includes multiple influent filters to remove turbidity, master dual-column demineralizer, scavenging carbon filter, polishing mono-column demineralizer, sub-micron effluent filter — all completely "packaged" on a single skid, ready to deliver an effluent of 18 megohms and better upon simple connection to service lines. (Other fully "packaged" Penfield systems available with capacities from 60 to 10,000 GPH.)

Pressure-Type Demineralizer "Polishes" to Ultra-High Purity at Point-of-Use



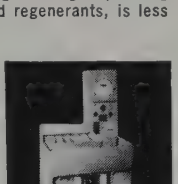
The Penfield PM-8 Demineralizer supplies up to 50 GPH of 18-22 megohm water — is ideal for point-of-use "polishing." Permanent cartridge design prevents raw water by-pass experienced with "canned" resin units. Cartridge unscrews by hand to permit easy resin renewal from bulk supplies, enabling substantial savings in replacement resin costs. Unit also can be charged for use as a cation exchanger, anion exchanger, carbon filter, oxygen or organic remover, and is adaptable for scavenging oil from gases.



In-Plant Regeneration Unit Saves 90% of Costs of Demineralized Water

A Penfield Regeneration Unit makes the renewal of exhausted resins from Point-of-Use Demineralizers an easy in-plant function. Operator merely feeds resin into unit, then turns a single master switch to control resin separation, regeneration, rinsing and proper re-mixing. Average operating cost, including all labor and regenerants, is less than 30c per cartridge.

Fully Integrated Weir Washer "Polishes," Heats, Monitors, Cascading Water



Integral filters and pressure-type demineralizers enable circulation of 18-22 megohm water through multiple partitioned tank of a special weir design that precludes stagnation. Direct reading conductivity meter permits instant monitoring at any of three check points. Novel clip bar makes replacing heat elements simple. (Penfield also constructs weir washer tanks in standard sizes or to customer specifications, using a wide variety of materials such as block tin, cast acrylic plastic, etc.)

15 years of ion exchange pioneering means that Penfield has on file field-proved answers to most industrial water problems — usually can detail the system you need by phone, ship your completely "packaged" units in a matter of days. Try a phone call or letter and see for yourself.

Penfield **Manufacturing Co., Inc.**
Telephone: BEverly 5-1694
19 High School Ave., Meriden, Conn.

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Circle No. 34 on Reader Service Card

New Literature

Slater Electric Inc., has announced the availability of its new series of silicon rectifier bulletins describing its miniature "Trim-Line." The new 26 page set of bulletins is a cross reference of the most popular JEDEC top hat numbers and includes characteristic curves and other engineering application information. The set also includes bulletin 1D-112 which describes special series of flangeless units up to 1.S amperes which permits direct wiring into the circuit without employing a heat sink.

Circle 150 on Reader Service Card

A new booklet on epitaxial germanium and silicon mesa transistors and epitaxial silicon mesa diodes has been made available by Sylvania. Entitled "A Case History in Progress," the new 8-page brochure contains the mechanical configuration and electrical characteristics of six new high speed switching epitaxial mesa transistors and four silicon mesa diodes. It also includes a typical circuit utilizing epitaxial units.

Circle 151 on Reader Service Card

Catalog Bulletin 3180.1 has been issued by Kinney Mfg. Division, The New York Air Brake Company, describing their Mechanical Booster High Vacuum Pumps, KMB Series. Bulletin gives general description, applications, performance, specification chart, modifications, etc. Fully illustrated with photos and typical pumping speed curves.

Circle 152 on Reader Service Card

The tri-clad alloy junction material, indium clad aluminum, recently announced by Accurate Specialties Co., Inc., is now fully described in a technical data bulletin designated Z-107. It describes the sequential melting process which makes the indium clad aluminum preform highly desirable in forming "P" type alloy junctions in germanium semiconductors. The bulletin further offers data as to cladding thicknesses available, preform sizes and tolerances.

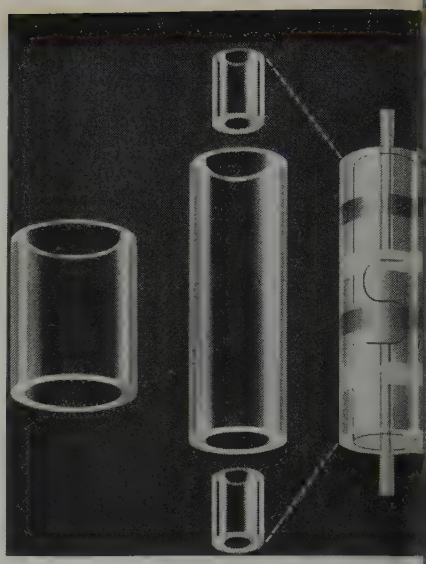
Circle 153 on Reader Service Card

General Electric Company has published a new 6-page brochure on its germanium n-p-n transistor, type 2N1289. According to the new bulletin, No. 30-67, the transistor combines high current gain, high frequency performance, low collector capacitance and low leakage current with a high emitter breakdown voltage.

Circle 154 on Reader Service Card

An information bulletin describing the characteristics and applications of Epoxy E-Form adhesive pellets is available from Epoxy Products Division, Joseph Waldman and Sons. Bond strength; thermal, electrical and chemical characteristics; production line bonding techniques; and curing are discussed in separate sections of the bulletin. Typical applications for epoxy adhesives are described in terms of bonding problem and solution.

Circle 156 on Reader Service Card



glass for you diode packages... precision drawn to specifications

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Parts ultrasonically scrubbed, chemically cleaned, and rinsed in deionized water. Shipped ready for your production line.

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Circle No. 35 on Reader Service Card

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EISLER 7½ KVA PRECISION VERTICAL SPOT WELDER

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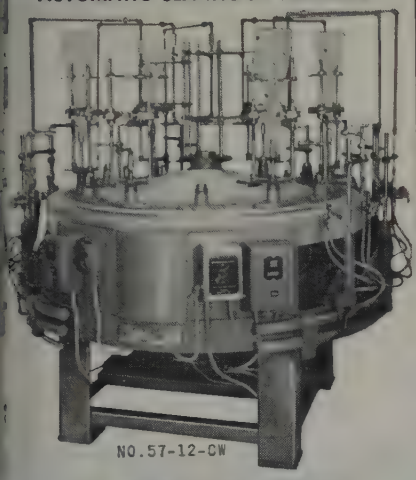
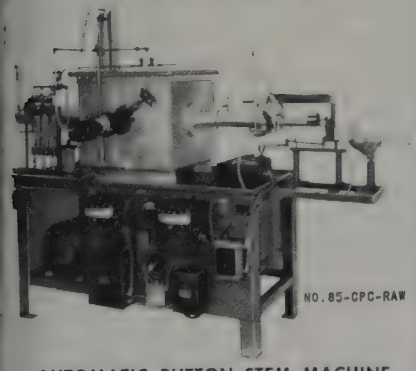
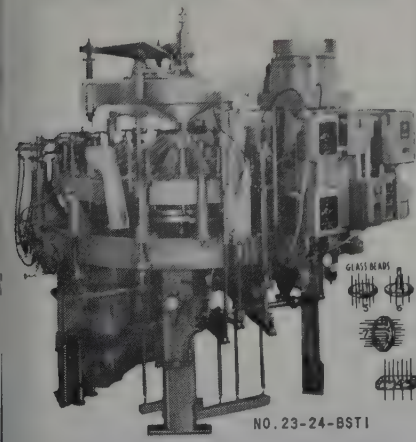


HIGH TEMPERATURE HYDROGEN ATMOSPHERE FURNACE



AUTOMATIC BUTTON STEM MACHINE



EISLER ENGINEERING CO., INC.
766 So. 13th St., Newark 3, N.J.
Circle No. 36 on Reader Service Card

Written in catalog style, an 8-page booklet gives a detailed presentation of Tektronix new high-speed laboratory oscilloscope. Designed for observation, measurement, and photographic recording of wideband phenomena, the Type 519 clearly displays waveforms with fractional-nanosecond risetime. The booklet contains specifications, performance characteristics, pertinent illustrations for various high-speed measurement applications.

Circle 157 on Reader Service Card

"The Way to Better Semiconductor Production" is the title of a new 20-page booklet in color issued by Lindberg Engineering Company. It describes and illustrates the many pieces of equipment now built by Lindberg for precision control in the production of semiconductors. The booklet also describes the laboratory as well as research and design services available.

Circle 158 on Reader Service Card

What is available for semiconductor design and manufacture? What metals or alloys? What type and size of spheres, to what tolerances, at what purities? What of discs, washers, cylinders, pellets, split rings, wire shapes, ribbons, castings? These and many other pertinent questions can readily be answered by a new, up-to-date report now available from Semi-Alloys, Inc.

Circle 159 on Reader Service Card

Just off the press, is the new edition of LABLOG, supplement to Will's General Catalog 7. Contains information on numerous laboratory instruments and apparatus.

Circle 160 on Reader Service Card

Design engineers, lab technicians and field engineers can greatly cut the time they usually spend gathering data about semiconductor diodes and rectifiers by using the new 300-page Characteristics Tabulation just published by Derivation and Tabulation Associates, Inc., Orange, New Jersey. Updated semi-annually, the April, 1961 edition (Volume 7) contains detailed specifications covering the 10,000 different types manufactured by every one of the 116 diode and rectifier manufacturers in the world.

Circle 161 on Reader Service Card

Two-color 8 page brochure announces the first of a family of Micrologic elements developed by Fairchild Semiconductor Corporation. The brochure describes applications and logic design with the Micrologic flip-flop in addition to providing diagrammatic drawings of the five other elements, all of which operate over the full military environment at bit rates above 1 mc.

Circle 162 on Reader Service Card

A four-page brochure listing the characteristics of 86 conventional glass silicon diodes is now available from Computer Diode Corporation. The catalog, D-100, of hermetically encapsulated diodes now in stock comprises 35 general purpose silicon diode types and 51 silicon computer diode types. The maximum power dissipation is 250mW at 25°C. The operating temperatures range from −65°C to +200°C.

Circle 163 on Reader Service Card

at HARVEY RADIO

DELCO RADIO SEMICONDUCTORS

are on the move!

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• NEW PRICES

HIGH POWER TRANSISTORS

TYPE	PACKAGE	PRICE
50 AMP. ROUND BASE		
2N1522	TO 36	$20.25
2N1523	TO 36	27.00
35 AMP. ROUND BASE		
2N1520	TO 36	11.65
2N1521	TO 36	15.40
25 AMP. ROUND BASE		
2N1518	TO 36	7.90
2N1519	TO 36	12.00
15 AMP. ROUND BASE		
2N1100	TO 36	**18.00**
2N1412	TO 36	**14.25**
2N1970	**TO 36**	**6.40**
2N1099	TO 36	10.50
JAN 2N174	TO 36	**16.50**
2N1358	TO 36	**16.50**
2N1358 (Sig. C)	TO 36	**16.50**
2N174A	TO 36	**16.50**
2N174	TO 36	7.15
2N173	TO 36	6.40
2N443	TO 36	6.00
2N278	TO 36	5.25
2N442	TO 36	4.90
2N277	TO 36	3.75
2N441	TO 36	3.40
5-7 AMP. DIAMOND BASE		
2N392	TO 3	4.50
2N1011	TO 3	5.25
2N1011 (Sig. C)	TO 3	10.50
2N1159	TO 3	5.25
2N1168	TO 3	3.00
2N1534	**TO 3**	**2.25**
2N1535	**TO 3**	**2.40**
2N1536	**TO 3**	**3.80**
2N456A	**TO 3**	**2.60**
2N457A	**TO 3**	**3.30**
2N458A	**TO 3**	**4.70**
2N1021	**TO 3**	**6.40**
2N1022	**TO 3**	**9.75**
2N1160	TO 3	5.65
3-4 AMP. DIAMOND BASE		
2N665	**TO 3**	**12.00**
2N665 (Sig. C)	TO 3	12.00
JAN 2N665	**TO 3**	**12.00**
2N669	TO 3	1.80
2N553	TO 3	6.00
2N1971	**TO 3**	**4.50**
2N297A (Sig. C)	TO 3	9.75
2N297A Com.	TO 3	4.90
1.5 AMP. MINIATURE DIAMOND		
2N1172	TO 37	3.45
2N1609	TO 37	5.85
2N1610	TO 37	7.15
2N1611	TO 37	4.15
2N1612	TO 37	5.25

POWER RECTIFIERS

TYPE	PACKAGE	PRICE
22 AMPERES		
1N1191A	DO 5	**2.60**
1N1192A	DO 5	**3.40**
1N1193A	DO 5	**4.50**
1N1194A	DO 5	**6.00**
40 AMPERES		
1N1183A	DO 5	**3.60**
1N1184A	DO 5	**4.35**
1N1185A	DO 5	**5.60**
1N1186A	DO 5	**7.50**

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Circle No. 37 on Reader Service Card

Graphite Facts

by George T. Sermon, President
United Carbon Products Co.

Is Bigness Bad?

I'm talking about size that has financial strength and capacity to produce quality goods in volume at fair prices . . . bigness that offers customers the finest technical skill and experience to be had.

Unfortunately, when you buy small, you may handicap your own growth potential. It's that simple!

Assume you have a new mesa transistor at the pilot plant stage. Your research says there's a strong market. Your graphite boats are purchased from a small job shop simply because of a minor price advantage. The pilot run is started.

Bonanza! The market research was right. The pilot plant transistors are selling fast. Competition begins to move. Now you order several hundred graphite boats.

The small job shop excitedly goes to three shifts and quality starts falling. In three months it is obvious you need several thousand boats before the end of the year. Then the program stalls! Competition really moves in to get the profits because you initially did not buy bigness to match the potential of your own product.

As a good guide to determine what size your source of graphite parts should be, ask "Does it have the capacity to meet the potential of our product?" United has that capacity.

UNITED carbon products co.

BOX 747 BAY CITY, MICHIGAN

Circle No. 38 on Reader Service Card

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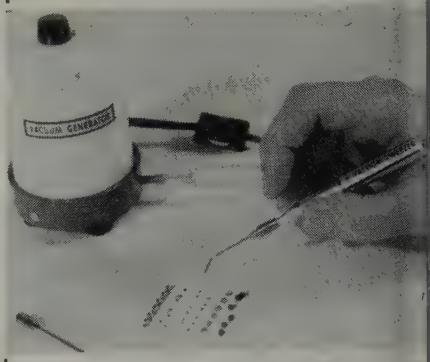

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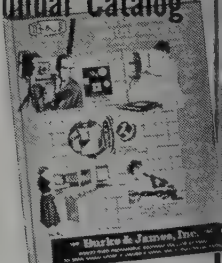

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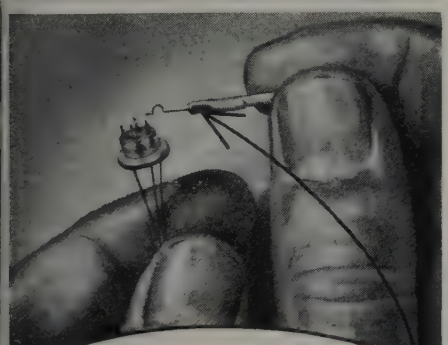

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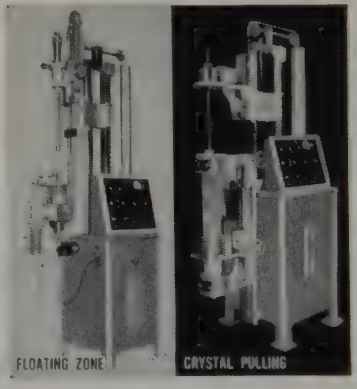

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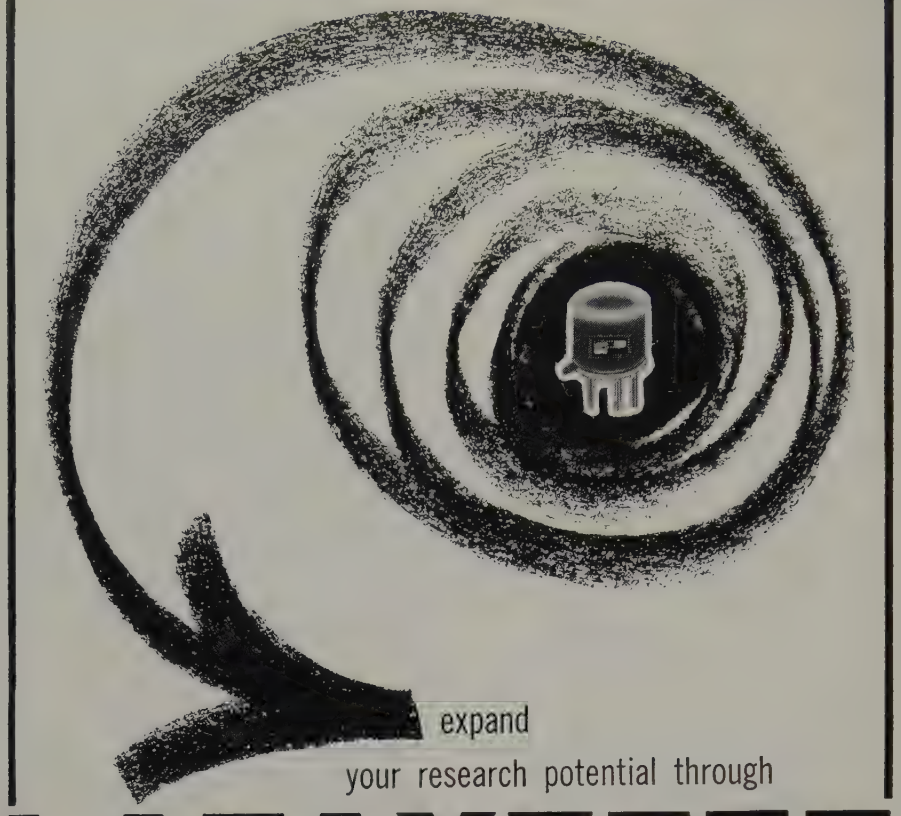

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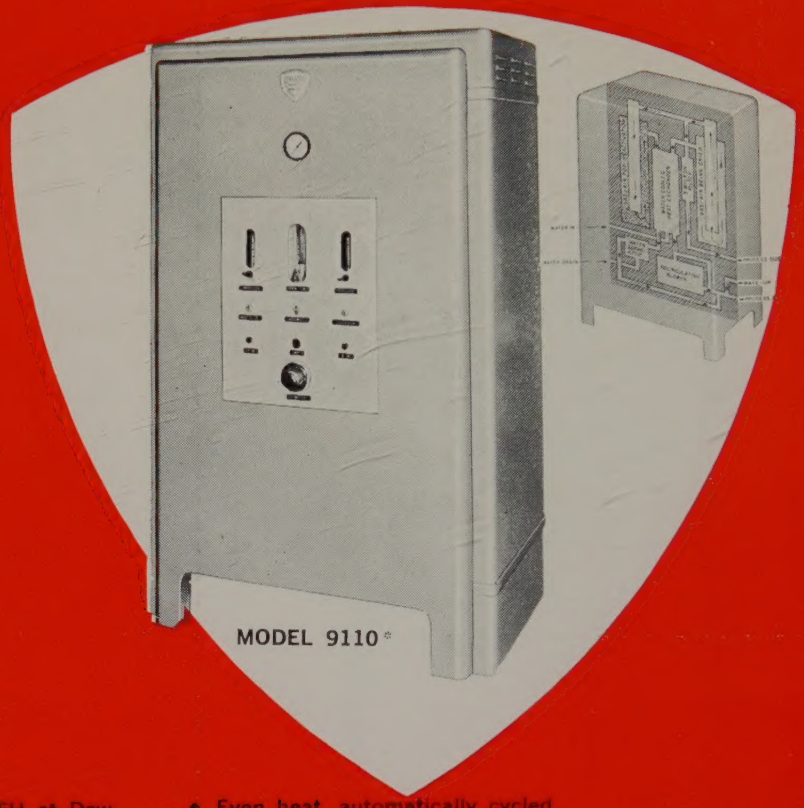

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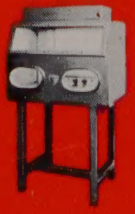
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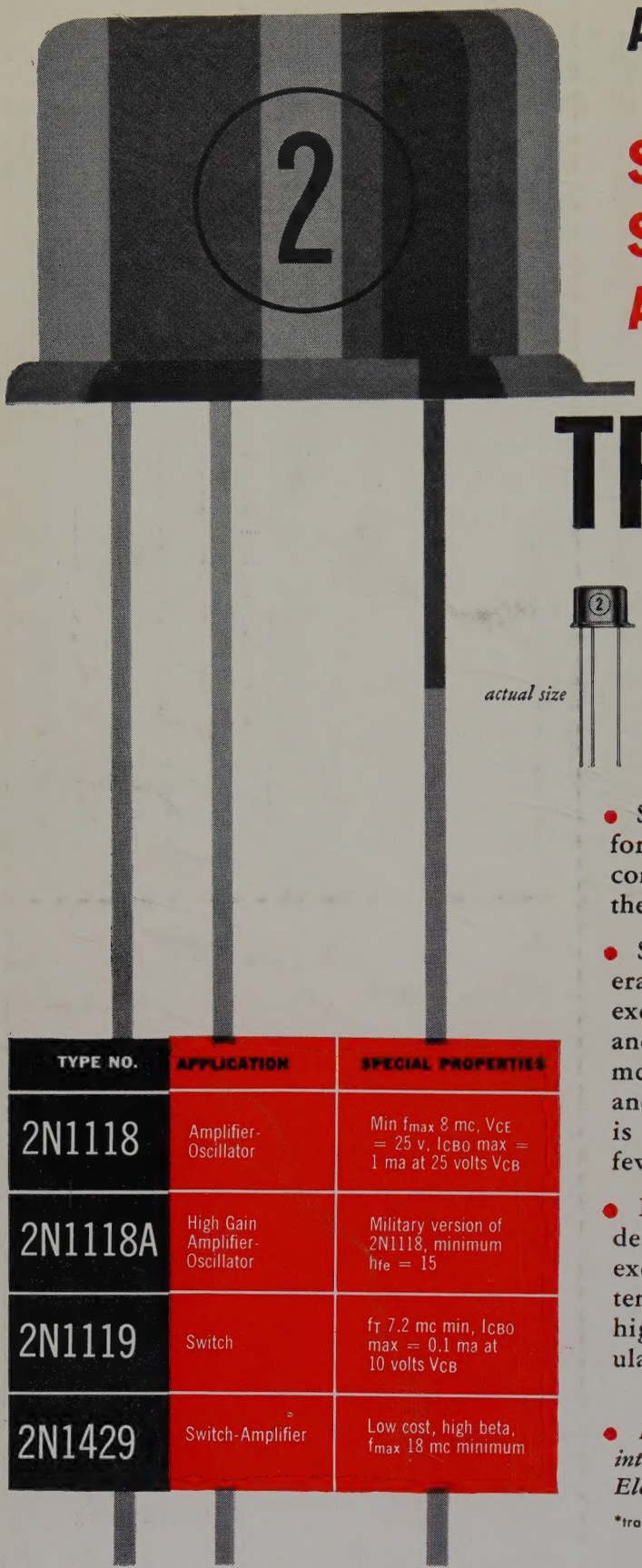

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